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EXPERIMENTAL AND STANDARD FORMATS FOR
PROCEDURAL INSTRUCTION: EVALUATION
OF MERGING PICTORIALS AND WORDS

BY

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B.S., Florida Technological University, 1977

THESIS

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Abstract

Three methods of training procedural tasks were studied.

Forty-five high aptitude and forty-five low aptitude Naval trainees from the Basic Electronics and Electricity School, Orlando, Florida, were given training with either a programmed instruction text with a pictorial-print information presentation format, a non-programmed text with a pictorial-print information presentation format, or a standard narrative text. The effects of instructional method and aptitude on the performance of a procedural task after 1 1/2 hours of study and after one week's time were evaluated.

It was shown that subjects who studied the programmed instruction text with the pictorial-print information presentation format made significantly ($p < .0001$) fewer performance errors, immediately after study and after one week, than did the subjects who studied the other methods. It was also shown that high aptitude subjects performed significantly ($p < .0001$) better than low aptitude subjects, regardless of training method. However, it was found that the low aptitude subjects who studied the programmed instruction text with the pictorial-print information presentation format performed significantly ($p < .01$) better than the low aptitude subjects who studied the other materials. These low aptitude subjects also performed significantly ($p < .01$) better than the high aptitude subjects who studied the standard narrative text.

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The development of instructional media to communicate technical information is an area of considerable interest to the military and industrial training communities. The effectiveness of such media is a major concern, and is directly affected by the format in which information is presented. Some training materials are not optimally effective due to inadequate information presentation formats. Ainsworth (1978) indicates that such a problem typically arises because learning theory principles are not sufficiently utilized during media preparation.

This thesis reports the development and field-test of several formats for teaching procedural tasks. A procedural task requires that a sequence of discrete responses occur in a specific spatial and temporal order (Briggs & Naylor, 1963). It is a combination of a mental skill - recalling response order, and a motor task - control positioning movements. For instance, the pre-flight check-out in an aircraft cockpit demands a specific ordered succession of dial setting and knob adjusting. A single step performed out of sequence or a step omitted could mean disaster. The "power up" of an assembly line is also a procedural task that requires a definite order of control manipulations to start the machinery working.

A prominent concern in instructional media development is the proper merging of pictorials and words to present proceduralized instructions. Gibson (1954), hypothesized that pictures and models are more effective than words for learning about concrete things

like tools and mechanisms, and about procedures and sequences. He suggests that pictures more closely approximate direct perception than do words, therefore, less associative learning needs to occur in order for pictures to depict their referents. However, words are more effective for presenting action-response information which is difficult to present unambiguously via a pictorial presentation (Booher, 1975). Booher (1975) suggests that instructions presented pictorially enable the reader to use cognitive processes involved in iconic imagery and pictorial perception to aid in comprehending such instructions.

Audio-visual communication researchers (Hartman, 1961; Gropper, 1963; Severin, 1967; Wicker, 1970) consider pictorial, auditory-verbal, and print the three major channels of information presentation. The relative effectiveness of audio and print channels have been studied using nonsense syllables and digits, meaningful words, and meaningful prose. Typically print is found to be more effective than audio as the difficulty of the material increases, provided subjects are literate. The effectiveness of the pictorial channel relative to audio and print is not as apparent. Hartmen (1961) reviews a number of studies showing the pictorial channel superior to audio and print, but points out methodological problems that tend to weaken the strength of such a generalization. For instance, the older studies used inadequate experimental design and measurement techniques; and in all the studies there was no control over the relative difficulty of pictorial and verbal items.

Single information presentation channels (pictorial, auditory-verbal, print) are frequently combined to form multiple channels. This simultaneously presented information may be redundant, such as, words spoken and printed; related, such as, a picture of an object and the word for that object; unrelated, such as a picture of an elephant and the number 27; contradictory, such as, a picture of a boy and the word girl. There is a general consensus that redundant presentation of audio and print is more effective than either audio or print alone (Hartman, 1961). Studies that compare related multiple channels, pictorial-verbal presentations vs. print alone or audio alone, strongly indicate the superiority of the combined channel approach.

The advocated supremacy of multiple channel presentation is accounted for by two theoretical viewpoints - cue summation and stimulus generalization. The cue summation principle essentially predicts that as the number of available relevant cues increase, so does learning. Miller (1957) suggests that cue summation supports a multimodality approach to instructional media development:

If one stimulus complex is to be distinguished from another, the subject may use any of a number of cues or stimuli in respect to which the complexes differ to make a discrimination between them, although a single cue is obviously sufficient. Increasing the number of cues available for making the discrimination increases the likelihood of a single subject's making the correct discrimination over a period of time.... In other words, the more handles there are, the easier it is to find one particularly suited to a given individual. When cues from different modalities are used simultaneously, they may either facilitate or interfere with each other. When the cues elicit the same response simultaneously or different responses in the proper succession, they should summate to yield increased effectiveness.

When the cues elicit incompatible responses, they should produce conflict and interference. (p.241)

Severin (1967) cites studies which indicated that pictures plus audio material resulted in more learning than did the audio channel by itself. The same concepts presented in either a combined or single mode were more readily comprehended when presented via the mixed channel.

Other authorities propose a stimulus generalization explanation for the increased effectiveness of a multiple channel approach.

It predicts that greater amounts of information are gained when the testing situation becomes increasingly similar to the presentation situation. Miller (1957) more precisely defines the principle:

Generalization between two stimulus complexes is a direct function of the number of cues they possess in common. The greater the number of cues held in common by the two stimulus complexes, the probability that the cues will also be presented in the second stimulus and will elicit a similar response increases. (p.242)

Rohal (1949) tested the stimulus generalization hypothesis by making photographs of knot tying from a variety of camera angles, and found that the photographs having camera angles identical to the view a person would have when actually tying a knot were the most successful in teaching the task. Lefkowitz (1955) demonstrated that the use of line drawings led to greater amounts of learning than still pictures when subjects were given a line drawing test. On the other hand, still pictures were found to be more effective than line drawings when tested on still pictures.

A consideration of both the cue summation and stimulus generalization principles is perhaps the best way to explain the effectiveness of multiple channel information presentation. Hartman (1961), argues that if learning is increased as the testing situation becomes more like the original learning condition, it may be expected that single channel testing will not fully elicit the learning that takes place with a multiple channel presentation. From a cue summation point of view, it is expected that adding cues to the stimulus to be learned increases the likelihood of evoking the desired response. However, these added cues will be virtually ineffectual if they are not presented in both acquisition and testing conditions. Furthermore, if the cues compete with one another to the extent that interference occurs, then the additional information does not serve its intended function.

A study that greatly influenced the development of the experimental format evaluated in this thesis is Booher's (1975) comparison of pictorial - print information formats for proceduralized instructions. Instructions, presented in six different picture-word formats, were created to be used with a programmable task simulator he designed to evaluate information presentation techniques. The content of each procedural step incorporated three specific kinds of information:

1. Context - includes the scope of actions that must be carried out.
2. Focus - more specifically defines the objects the reader must attend to and perform certain actions on.

3. Action-step - operationally defines the performance action

For instance, one written instruction was as follows: "Set POWER switch to ON position on SIMULATOR panel. Check POWER lamp illuminates." SIMULATOR panel tells the context, focus is conveyed in the words POWER switch and lamp, and the action-steps are: Set switch to ON, and check lamp illuminates. Table I summarizes these picture-word formats.

His results clearly showed that highly pictorial multiple channels (HIGH PIC REL PRINT, HIGH PIC REDUN PRINT) required less performance time and produced less performance errors than did any of the other formats. The most efficient understanding of procedural instructions occurred with a multiple channel presentation arranged so that pictures were the primary communication channel and printed words served as a secondary channel to clarify the illustrations (HIGH PIC REDUN PRINT).

Finally, Booher presents several pertinent theoretical implications. To begin with, his findings tend to cast doubt on the cue summation explanation of the superiority of a multiple channel approach. It proposes that by adding cues to the stimulus to be learned the likelihood of evoking the desired response is increased. This rationale cannot, however, account for his findings that the highly verbal multiple channels (HIGH PRINT REL PK; HIGH PRINT REDUNDANT PIC) produced more errors than the print channel alone. Instead, he proposes his findings may indicate the existence of different types of memory processing as suggested by Haber (1970).

Table 1
Experimental Conditions in Booher's (1975) Study

Formats	Descriptions
PRINT	Single-channel information presentation. Printed words and numbers only.
PIC	Single-channel information presentation. Pictorial illustration only. Names on apparatus replace with alphanumeric symbols.
HIGH PIC REL PRINT	Primarily pictorial mode of presentation. Pictorial view of general context, and focus information for each step of each instruction, by short verbal statements of each action. Information between channels related but low in redundancy.
HIGH PRINT REL PIC	Primarily verbal mode of presentation. Printed word instructions and word names used to identify specific areas, objects, and positions. A general picture with word-arrow locators used to provide location information.
HIGH PRINT REDUN PIC	Written instructions similar to HIGH PRINT REL PIC. Redundant pictorial focusing techniques and word names used to identify specific areas, objects, and positions.
HIGH PIC REDUN PRINT	All information presented Pic except name used instead of symbol. In addition, printed words for actions provided with each step. Information redundant between channels.

Booher (1975) suggests there may be two avenues for information processing through the comprehension stages. The first is essentially a pictorial one which "translates from pictorial inputs directly to select a range of routines to use in completing the tasks and organizing them in a time sharing manner." The second is a verbal processing mechanism which "translates verbal inputs in a more step-by-step manner, tending to search and select routines in series."

The highly verbal multiple channel formats used in this study are conventional textbook proceduralized instructions. Booher suggests that the inefficiency of such formats occurs because they are not adequately organized to take advantage of the distinct internal pictorial and verbal processing capabilities. He further indicates the enhanced performance from using highly pictorial formats may be because "subjects are getting advanced information, in nearly the same time frame, about many of the subroutines needed to carry out the task." He points out that individuals may be getting information about several object-action relationships to form what he calls a perceptual blueprint that optimally organizes a series of perceptual-motor actions. In conclusion, Booher states that the "human processing system is more efficient in comprehension of instructions when the pictorial mode is used to aid in selection and organization of a range of perceptual-motor action and the verbal material is available to confirm specific action within the range."

Of relevance to the notion of a pictorial processing function is the use of visualization or visual imagery in the retention and

transfer of procedural tasks. Jenkins (1935) showed that visual imagery plays a part in the recall of specific items, but that words were necessary to learn concepts. Smith (1971) found that the use of visual imagery was effective in long term memory but showed no significant effect on short term memory. Dansereau, Long, McDonald, Actkinson, Collins, Evans, Ellis, and Williams (1975) have successfully used visual imagery strategies to enhance student performance in various learning situations.

A final important consideration is the development of an instructional delivery system. Aagard and Braby (1976) have established guidelines for teaching procedural behaviors, based on learning theory principles. These guidelines utilize the learning principles of information chunking (dividing procedure into sections), chaining (putting single steps into a sequence), practice (of individual steps, sections, total procedure), self-testing (after each step, section, total procedure), prompting (guiding responses on test), immediate knowledge of results, reinforcement, and distributed practice and overlearning (repetition and practice of entire procedure beyond that required for immediate performance). In addition, they outline particular learning events and activities that should be built into a procedural skill training system.

Programmed instruction incorporates these guidelines. Furthermore, it has been successfully and widely used in the Air Force to train procedural skills, like, the care and maintenance of aircraft mechanic's hand tools (Coleman, 1964), and the mechanical maintenance of a K-38 revolver (Lang & Melton, 1964). And it has been used by

the Canadian Armed Forces in training technicians to install replacement engines in aircrafts (Catano, 1976).

Dwyer (1967) evaluated the relative effectiveness of various visual illustrations in complementing programmed instruction. He gave four groups of college students programmed instruction (on the human heart) with varied illustrations (no illustrations, simple line drawings, detailed shaded drawings, realistic photographs). After studying the packages, immediate retention was measured on five different tests (drawing, identification, terminology, comprehension, total understanding of concepts). His results showed the photographic presentation to be most effective for total understanding of concepts, learning specific locations of various parts of the heart and recalling patterns (drawing test), and identifying parts of the heart on a detailed drawing (identification test). Programmed instruction without visuals was found to be as effective as the visually complemented treatments in remembering terminology and in comprehension of the internal operations of the heart.

In summary, the literature points out three factors are important to the development of training materials for procedure learning. They are: 1) the format in which information is presented, 2) the instructional delivery system used to present the information, and 3) the principles of learning that should be followed in order to maximize retention of procedural skills. It has been shown that a format in which pictorial and printed information are redundant is optimal for proceduralized instruction. Also, programmed instruction

was found to be a successful instructional delivery system for procedure learning. And finally, it has been suggested the learning principles of information chunking, reinforcement, chaining, distributed practice, overlearning, and immediate knowledge of results should be built into procedural skills training systems.

As a logical extension of the theoretical issues and findings presented above, it appears that a programmed instruction text which applies the learning principles and activities outlined in the procedure learning algorithm (Aagard and Braby, 1976), and which utilizes a pictorial-redundant print presentation format, may be an effective media for proceduralized instruction. The specific purpose of this thesis is to evaluate the effectiveness of such a training method, and to test the following hypotheses:

- 1) The Pictorial Guided Practice training method will result in more accurate performance (fewer errors) than will either the Standard Narrative or the Pictorial Only texts.
- 2) High aptitude subjects will perform more accurately than low aptitude subjects regardless of training method.
- 3) Low aptitude subjects using the Pictorial Guided Practice method will perform more accurately than low aptitude subjects using either the Standard Narrative or Pictorial Only texts.

Method

Subjects

Ninety Naval trainees in the Basic Electricity and Electronics (BE&E) School at Naval Training Center, Orlando, Florida, participated in the study. Forty-five high and 45 low aptitude subjects were selected on the basis of their scores on Arithmetic Reasoning (AR), Work Knowledge (WK), and Mechanical (MC) subtests of the Armed Services Vocational Aptitude Battery (ASVAB). This composite score is in fact the primary selection criterion for entrance into the BE&E School. High aptitude was arbitrarily defined by an AR+WK+MC score of 184 or above (top one-third among BE&E students). Low aptitude was defined by a score of 147 or below (bottom one-third). Fifteen individuals from each aptitude group were randomly assigned to each of the three instructional conditions.

Design

The experimental design is classified as a 3 (method) x 2 (aptitude) x 3 (trials) factorial with repeated measures on the last factor.

Apparatus

A Tektronix 545B oscilloscope was used for performance testing.

Training Materials

Pictorial Guided Practice Handbook. This 116 page package presents the probe calibration procedure using a photographic/ redundant print presentation format, and implements many of the guidelines for procedure learning established by Aagard and Braby (1976), in a programmed instruction format. Appendix D contains these guidelines. The specific learning principles and activities incorporated in this text are shown in Table 2. A sample of the handbook is provided in Appendix C.

Pictorial Only Handbook. This 20 page package is essentially a subset of the Pictorial Guided Practice Handbook. It presents the probe calibration procedure using photographs with redundant printed directions, but does not include any of the practice exercises, self-tests, or feedback contained in the expanded version. The learning guidelines it does incorporate are: 1) Orients student to learning task by stating objectives, reasons for learning task, and how training is organized to achieve objectives; 2) Provides a demonstration of the procedures to serve as a correct model; 3) Maximizes realism by presenting equipment in enough detail to provide necessary cues; and 4) Presents information in a clear and readable format. A sample of this handbook is presented in Appendix B.

Standard Narrative Text. This 21 page booklet has the same format as the text currently used in the Basic Electricity and

and Electronics School's Basic Electricity and Electronics Student's Guide, (1978). It discusses the functions of basic oscilloscope controls and presents the steps of the probe calibration procedure, and is used in conjunction with the actual equipment. The procedure learning guideline it incorporates is: Orients student to learning task by stating objectives and reasons for learning task, and how training is organized to achieve objectives. This text is presented in Appendix A.

Table 2

Procedure Learning Guidelines Implemented in Experimental Format

Orients student to learning task by stating objectives, reasons for learning task, and how training is organized to achieve objectives.

Chunking - divides procedure into steps for the recall and practice of individual steps, and then chain all steps into a sequence.

Provide frequent self-tests for students to monitor their progress.

Provide a demonstration for the procedure to serve as a correct model

Maximize realism- equipment should be presented in enough detail to provide necessary cues.

Early in training use:

- a. immediate and frequent knowledge of results.
- b. immediate and frequent reinforcement
- c. little or no operational distractors
- d. guiding and prompting of responses

Support, and encourage the mental rehearsal of the procedure.

Provide for slow learners to have as many successful performances as fast learners.

Present information in a form that is clear and appropriate for the reading skill of the student.

Procedure

Initially each subject was instructed about the purpose of the study and procedures to be followed. Subject in Group 1 were trained using the Standard Narrative Text. Subjects in Group 2 used the Pictorial Only Handbook, and subjects in Group 3 used the Pictorial Guided Practice Handbook.

All subjects regardless of training method were allowed a total of 90 minutes to learn the probe calibration procedure.

Each subject received one training trial with his respective package. Time to complete this trial was recorded. A criterion test was given requiring the subject to perform the probe calibration procedure on the oscilloscope. Time to complete the task, control setting errors, and sequence errors (ommission, commission, reversal) were recorded as measures of proficiency. A multiple choice Job Knowledge Test (JKT) was administered after the first training trial and the order was counterbalanced so that 50% of the individuals in each group received the JKT before performance testing and 50% received it after the performance test.

Subjects were then allowed to return to their training materials for a practice session. The amount of time each subject was given during the practice phase was determined by subtracting the amount of time he took to complete the first learning trial from the 90 minutes allotted for total training. At the end of the practice trial subjects were required to perform the calibration procedure on the oscilloscope. The same performance measures were again used.

One week after training subjects were required to take the same performance test, this time as a measure of skill retention.

Results

The effects of instructional method, aptitude, and experimental trials on the performance of the probe calibration procedure were analyzed by a 3x2x2, repeated measures on the last factor, analysis of variance and a Scheffé post hoc procedure. These analyses are summarized in Table 3 and 4.

The result of primary interest was that the method of training significantly affected task performance $F(2,84)=46.03$, $p<.0001$. Mean errors for the Pictorial Guided Practice (PGP), Pictorial Only (PO), and Standard Narrative (SN) groups were 2.8, 7.24, and 9.09, respectively. Figure 1 depicts the method main effect. The Scheffé test indicated that subjects who studied the Pictorial Guided Practice handbook made significantly fewer errors than subjects who studied the Pictorial Only and Standard Narrative texts, $F(1,84)=43.04$, $p<.01$; and $F(1,84)=86.38$, $p<.01$, respectively.

The Analysis of Variance showed that aptitude also significantly affected the performance of the procedural task $F(1,84)=29.01$, $p<.0001$. Mean errors for the high aptitude subjects were 5.7 and 7.9 for low aptitude subjects. Figure 2 shows that the low aptitude subjects who studied the Pictorial Guided Practice text made fewer errors than either the high and low aptitude subjects who studied the other instructional materials. The Scheffé test indicated that

Table 3
3x2x3 Analysis of Variance on Performance Errors

Source	SS	df	MS	<u>F</u>
Method	1899.23	2	949.61	43.03**
Aptitude	598.53	1	598.53	29.10**
Method x Aptitude	24.80	2	12.40	.60
Trials	1312.14	2	656.07	203.88**
Method x Trials	209.04	4	52.26	16.24**
Aptitude x Trials	2.15	2	1.08	.33
Method x Aptitude x Trials	40.04	4	10.01	3.11*

* $p < .05$

** $p < .01$

Table 4
Scheffé Test Summary

Source	SS	df	F
Method			
PGP vs. PO	19.71	1	43.03*
PGP vs. SN	39.56	1	86.38*
Aptitude			
PGP,low vs. SN,low	45.16	1	49.49*
PGP,low vs. PO,low	34.69	1	38.02*
PGP,low vs. SN,high	13.32	1	14.60*
PGP,low vs. PGP, high	7.34	1	8.05*
PGP,low vs. PO, high	2.72	1	2.98
Method x Aptitude x Trials			
PGP,high vs. PO,high + SN,high at Trial 2	4.14	2	4.59
PGP,low vs. PGP,high + PO,high +SN,high at Trial 2	.13	3	.04
PGP,low vs. PO,low + SN, low at Trial 2	4.96	2	9.18*
Method x Trials			
PGP,1 vs. PGP,2 + PGP,3	5.95	2	4.40

* $p < .01$

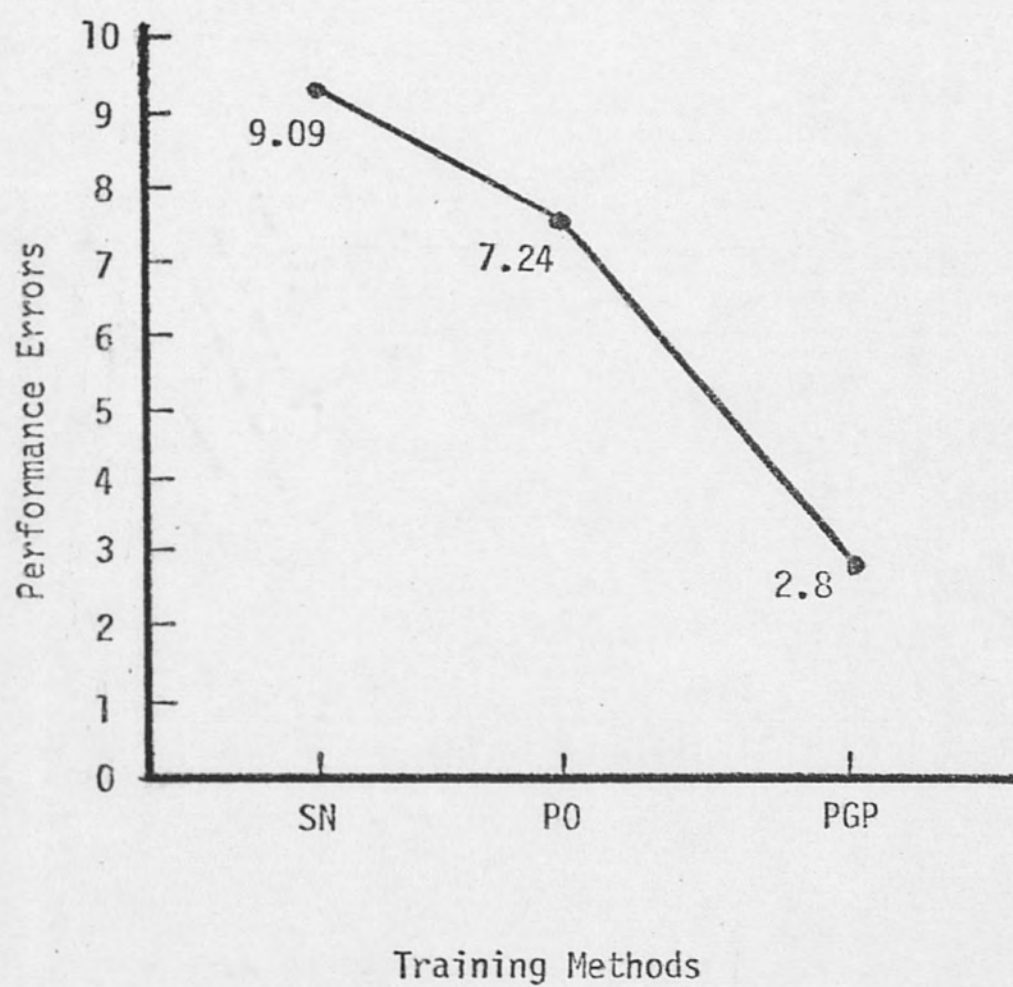


Figure 1. Method Main Effect

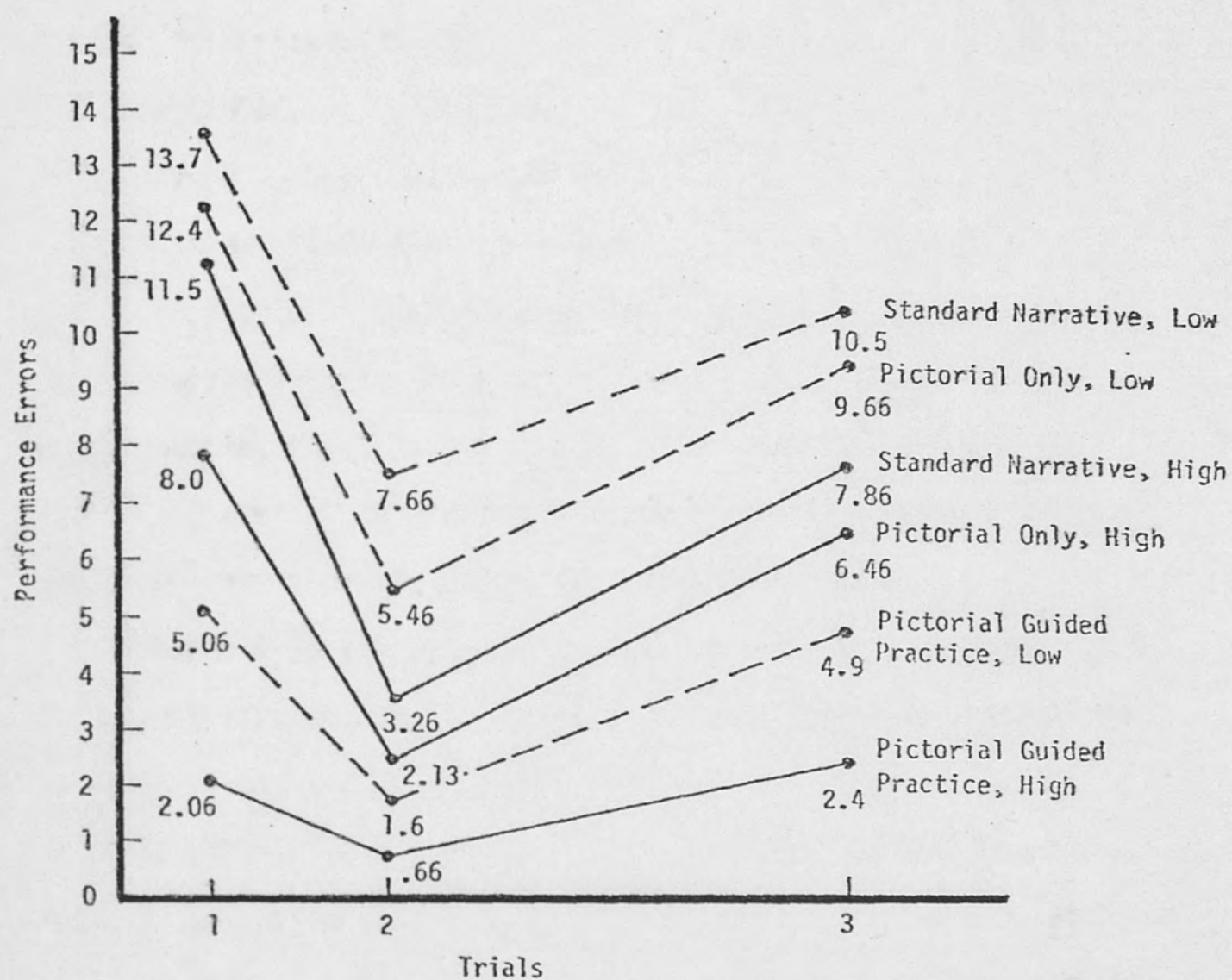


Figure 2. Relationship of Method, Aptitude and Trials on Performance

the low aptitude Pictorial Guided Practice group performed significantly better than the low aptitude Standard Narrative and Pictorial Only groups, $F(1,39)=49.49$, $p < .01$; and $F(1,39)=38.02$, $p < .01$, respectively. They also performed significantly better than the high aptitude Standard Narrative group, $F(1,39)=14.60$, $p < .01$. The low aptitude Pictorial Guided Practice subjects did not, however, perform significantly different than the high aptitude Pictorial Only subjects, $F(1,39)=8.05$, $p < .01$. In comparison to the high aptitude Pictorial Guided Practice group, the low aptitude subjects, performed significantly worse, $F(1,39)=2.98$, $p < .01$.

The ANOVA further showed that experimental trials significantly affected performance of the calibration procedure, $F(2,168)=203.88$, $p < .0001$. This effect is depicted in Figure 3.

The ANOVA also indicated that the method, aptitude, and trials factors interacted to significantly affect task performance, $F(4,168)=3.11$, $p < .02$. It can be seen in Figure 4 that an ordinal method x aptitude interaction occurred on the second trial. A 3x2 analysis of variance at each trial indicated that only the Trial 2 interaction approached significance, $F(2,84)=2.99$, $p < .055$. The 3x2 ANOVA's are summarized in Table 5, 6 and 7. The Scheffé test on Trial 2 data showed that the mean performance errors for the high aptitude Pictorial Guided Practice ($\bar{X}=1.66$), Pictorial Only ($\bar{X}=2.13$) and Standard Narrative ($\bar{X}=3.26$) subjects were not significantly different from one another, $F(2,27)=2.71$, $p < .01$. In addition, no significant differences were found between the performance of the low

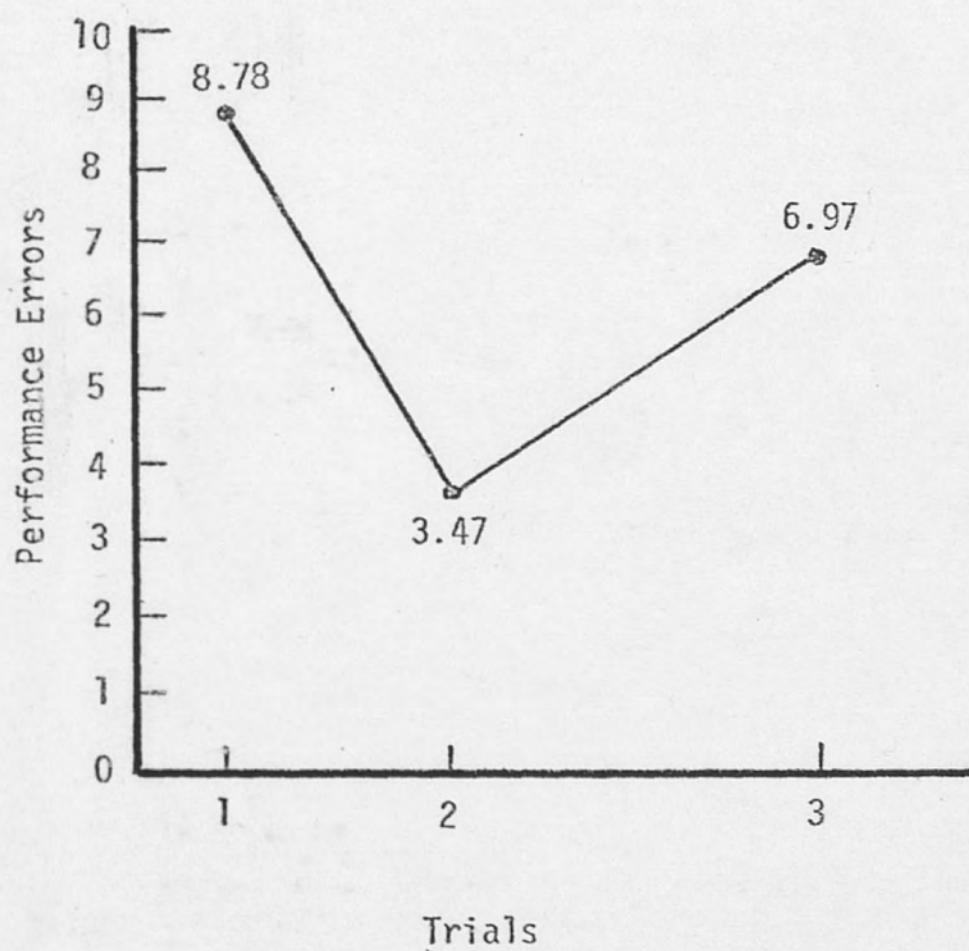


Figure 3. Trials Main Effect

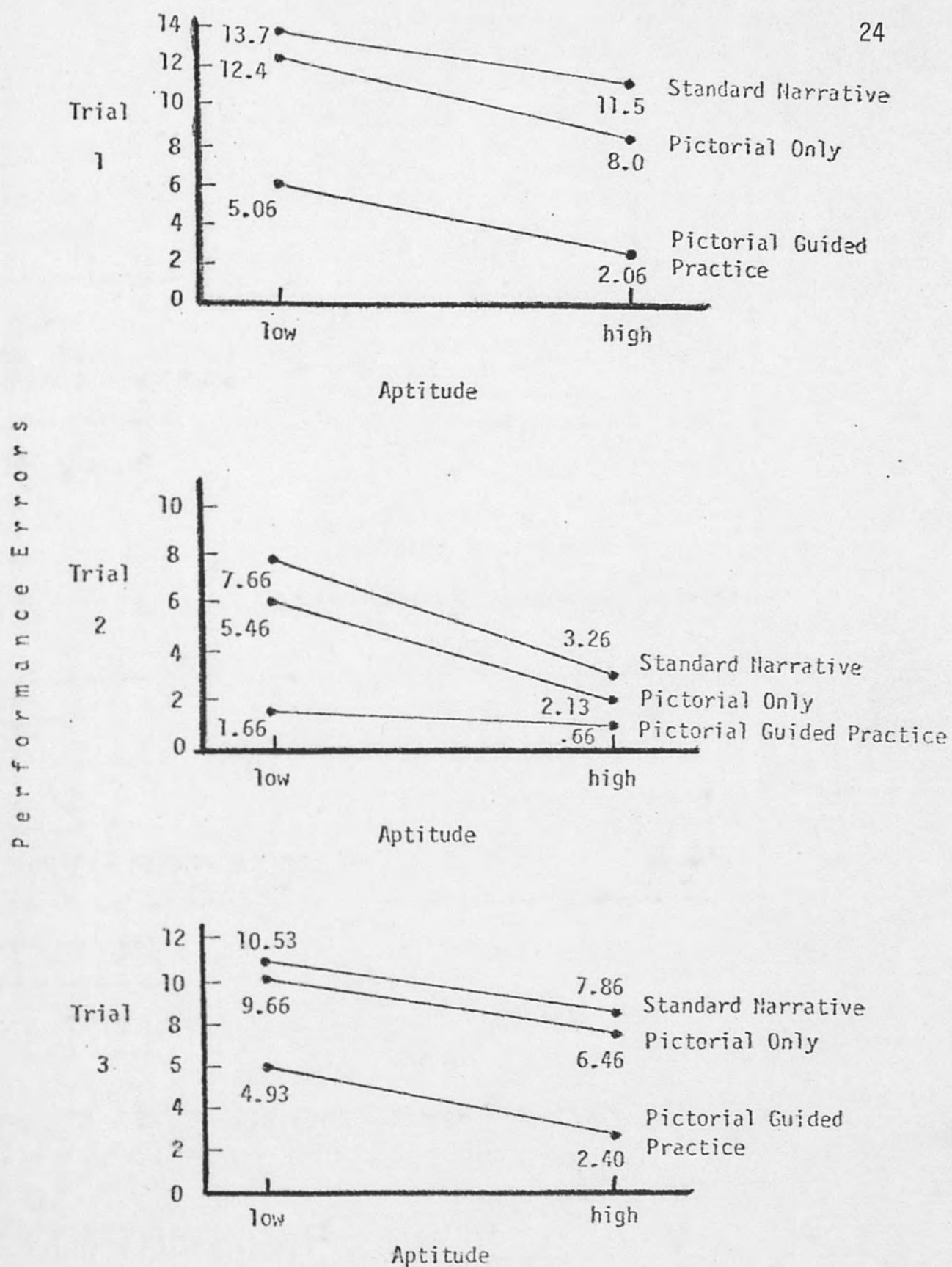


Figure 4. Method X Aptitude X Trial Interaction

Table 5

3x2 Analysis of Variance for Errors, at Trial 1

Source	SS	df	MS	<u>F</u>
Method	1313.622	2	656.811	60.09 **
Aptitude	233.611	1	233.611	21.37 **
Method x Aptitude	17.622	2	8.811	.45

** $p < .01$

Table 6

3x2 Analysis of Variance for Errors, at Trial 2

Source	SS	df	MS	<u>F</u>
Method	282.02	2	141.01	18.61 **
Aptitude	190.67	1	190.67	25.17 **
Method x Aptitude	45.35	2	22.67	2.99 *

* $p < .055$ ** $p < .01$

Table 7

3x2 Analysis of Variance for Errors, at Trial 3

Source	SS	df	MS	<u>F</u>
Method	512.62	2	256.31	29.94 **
Aptitude	176.40	1	176.40	20.61 **
Method x Aptitude	1.86	2	.93	.11

** $p < .01$

apptitude Picotrial Guided Practice subjects and all high aptitude subjects, $F(3,41)=.035$, $p < .01$. The Scheffé test did, however, indicate that the low aptitude Pictorial Guided Practice subjects made significantly fewer performance errors than did the low aptitude subjects who studied the other methods, $F(2,27)=9.18$, $p < .01$.

Finally, the ANOVA showed that the method and trial factors interacted significantly to affect task performance, $F(4,168)= 16.24$, $p < .0001$. It is shown in Figure 5 that this interaction occurred between trials and the Pictorial Guided Practice method. The Scheffé test indicated no significant differences in mean performance error at each trial for this method, $F(2,27)=4.40$, $p < .01$.

The effects of type of instructional method, aptitude, and trials on task performance time were also analyzed by a $3 \times 2 \times 3$, repeated measures on the last factor, analysis of variance. The ANOVA is summarized in Table 8. It showed that only the aptitude and the trials factors significantly affected the amount of time it took to calibrate the oscilloscope probe, $F(1,84)=9.2$, $p < .0032$; and $F(2,168)=61.67$, $p < .0001$, respectively. On the average, high aptitude subjects performed the task faster than low aptitude subjects. In addition, the amount of time it took subjects to calibrate the probe decreased from the first trial to the second and increased from the second to the third trial. Both effects are shown in Figure 6.

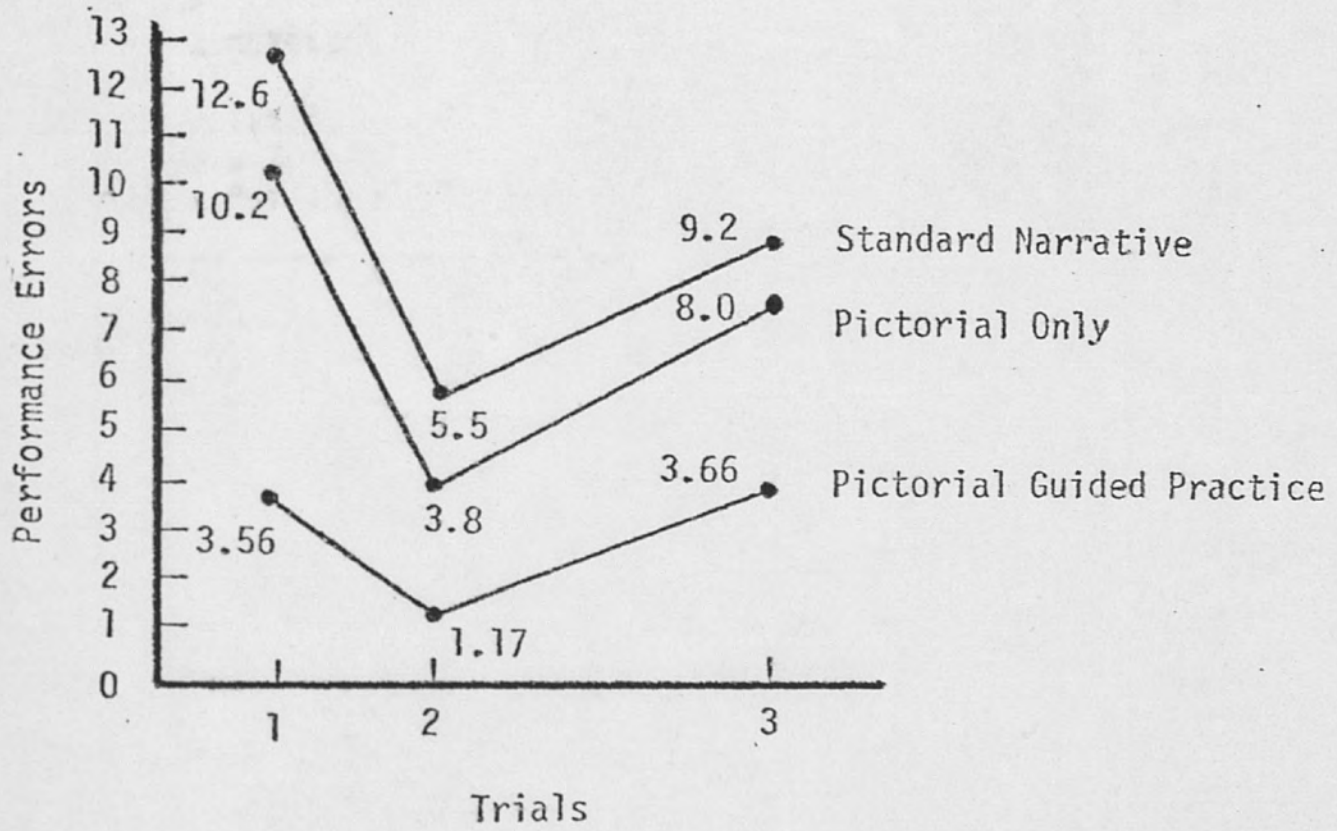


Figure 5. Method X Trials Interaction

Table 8

3x2x3 Analysis of Variance on Performance Time

Source	SS	df	MS	F
Method	3687.756	2	1843.87	.18
Aptitude	93409.200	1	93409.20	9.21*
Method x Aptitude	9098.866	2	4549.43	.45
Trials	427089.066	2	213544.53	61.67**
Method x Trials	9362.244	4	2340.56	.62
Aptitude x Trials	13379.288	2	6689.64	.15
Method x Aptitude x Trials	9299.311	4	2323.83	.61

* p .05
 ** p .01

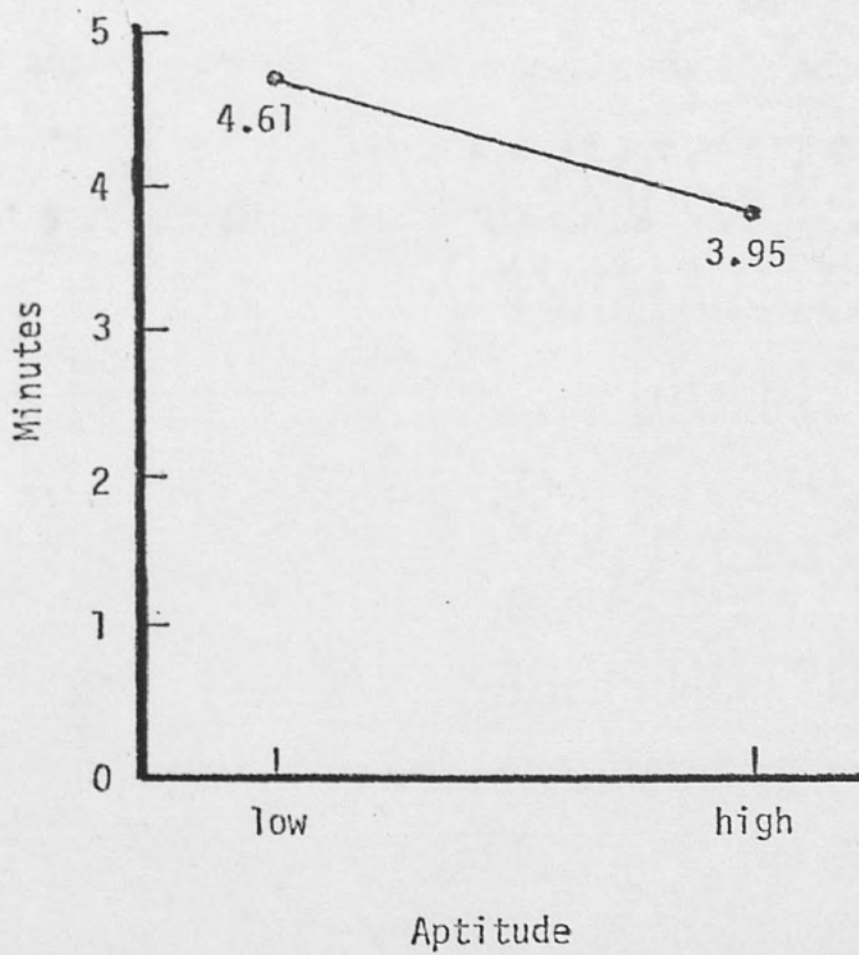
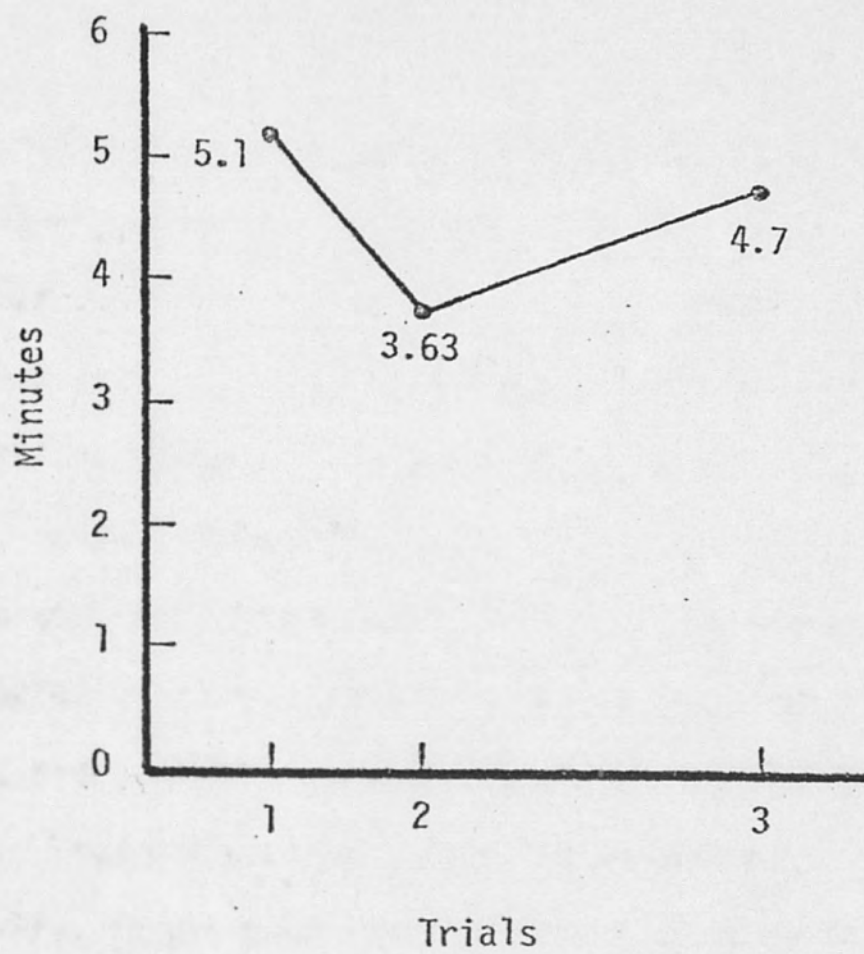


Figure 6. Trial and Aptitude Main Effects

The effects of instructional method and aptitude on performance on a multiple choice Job Knowledge Test were analyzed by a 3x2 analysis of variance. The ANOVA is summarized in Table 9. It showed that both instructional method and aptitude significantly affect test performance, $F(2,84)=5.54$, $p < .0055$; and $F(1,84)=60.18$, $p < .0001$, respectively. The subjects who studied the Standard Narrative text made fewer errors than subjects who studied either the Pictorial Only or Pictorial Guided Practice materials. As expected, high aptitude subjects made fewer errors than low aptitude subjects. Figure 7 depicts both of these effects.

Finally, it was shown that the amount of study time in Trial 1 varied depending on instructional method. It took the Standard Narrative group an average of 60 minutes, the Pictorial Only group an average of 29 minutes, and the Pictorial Guided Practice group an average of 67.5 minutes to study their handbooks one-time through.

Table 9
3x2 Analysis of Variance for Job Knowledge Test

Source	SS	df	MS	F
Method	67.75	2	33.88	5.54 **
Aptitude	368.04	1	368.04	60.18 **
Method x Aptitude	26.28	2	13.14	.122

** p .01

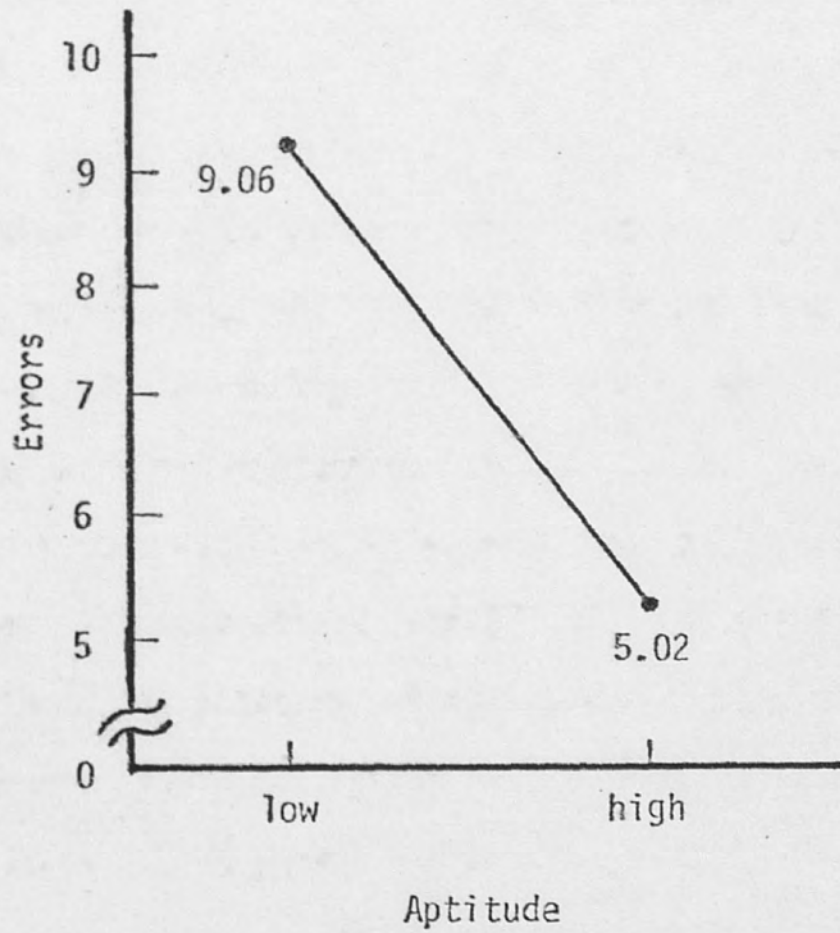
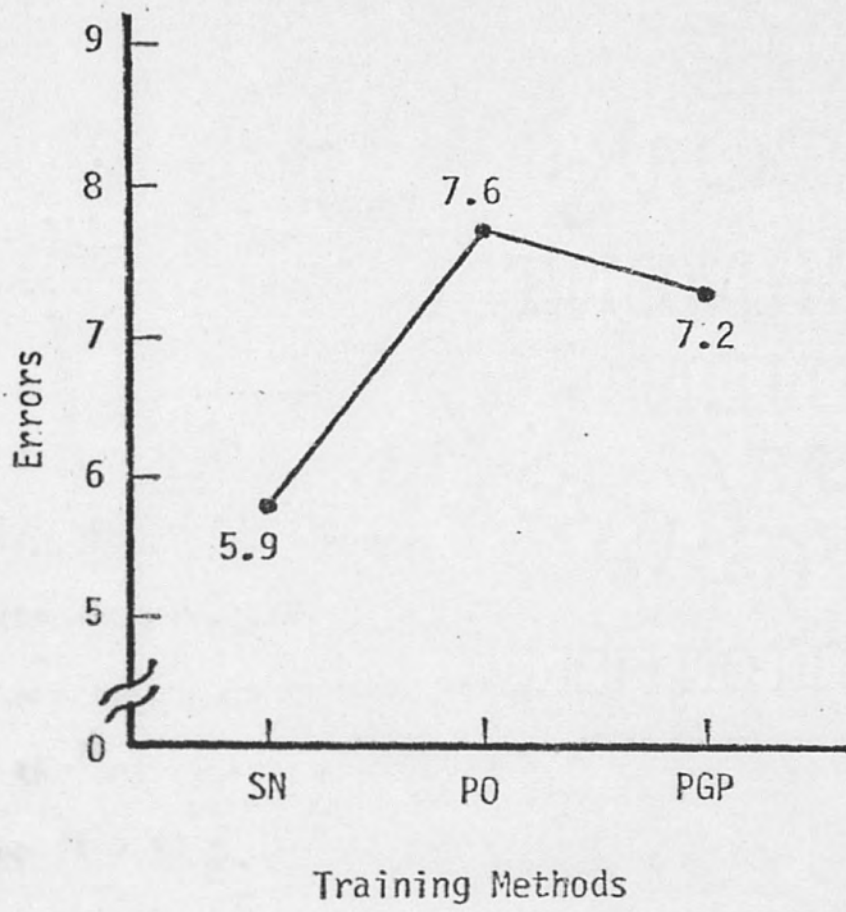


Figure 7. Method and Aptitude Main Effects for Job Knowledge Test

Discussion

All major experimental hypotheses were supported by the results of this study. The hypothesis that training with the Pictorial Guided Practice method would result in the best performance is supported by a strong method main effect and by post hoc comparisons showing that the mean performance error of the Pictorial Guided Practice group ($\bar{X}=2.8$) is significantly lower than the mean performance for both the Pictorial Only ($\bar{X}=7.24$) and the Standard Narrative ($\bar{X}=9.09$) groups. These results are in accord with Booher's (1975) findings that the most efficient learning of a procedural skill occurred when information was presented in a multiple channel format in which pictures were the primary communication channel and printed words were a secondary channel used to clarify and give focus to the pictorials. These findings are also in agreement with Dwyer (1967), who showed that photographs are the best visual illustration to merge with programmed instruction when the goal of training is to learn the specific location and identification of parts of a given system, and to recall patterns. Finally, these results demonstrate the effectiveness of the Aagard and Braby (1976) procedure learning guidelines within a programmed instruction context.

In terms of performance on the multiple-choice Job Knowledge Test, however, the results were essentially reversed - subjects who

studied the Standard Narrative text performed significantly better than the subjects who used the Pictorial Guided Practice and Pictorial Only handbooks. This apparent shift in the effectiveness of the training materials is predictable from a stimulus generalization point of view which proposes that greater amounts of information can be gained when the testing situation becomes increasingly similar to the presentation situation. It was expected, therefore, that the Standard Narrative text would in fact result in better performance on a test that used printed words as stimulus cues, and that the pictorial texts would result in better performance on a test that utilized spatial and temporal stimulus cues.

The second hypothesis that high aptitude subjects would make fewer performance errors than low aptitude subjects, regardless of type of instructional materials, was also supported. The aptitude main effect showed that the mean performance of the high aptitude subjects ($\bar{X}=5.9$) is significantly lower than the mean performance error for the low aptitude subjects ($\bar{X}=7.9$).

The third hypothesis that low aptitude subjects who studied the Pictorial Guided Practice text would make fewer performance errors than the low aptitude subjects who studied the other training materials was supported by significant post hoc mean comparisons. Mean comparisons further showed that the low aptitude Pictorial Guided Practice subjects performed better than the high aptitude Standard Narrative subjects, and performed as well as the Pictorial Only subjects. However, they did make significantly more errors than

the high aptitude Pictorial Guided Practice group.

The Method x Aptitude x Trials interaction was not considered important enough to qualify the interpretation of the significant main effects because it was only significant at the $p = .055$ level, and was merely an ordinal interaction which affected changes in the degree but not the direction of the relationship of method and aptitude on performance. Secondly, the F-ratio of the method main effect at Trial 2 (See Table 7) was six times larger than the F-ratio of the method x aptitude interaction, $F(2,84) = 18.61$ vs. $F(2,84) = 2.99$, suggesting that the strength of the method effect was greater than the strength of the interaction effect. Finally, it was shown in the Results that after 90 minutes of study, the performance levels of all high aptitude subjects and the low aptitude Pictorial Guided Practice group were virtually errorless. This indicates that the interaction may be an experimental artifact due to a ceiling effect.

It was also shown in the Results of the significant Method x Trials interaction effect was occurring between trials and the Pictorial Guided Practice method. The Scheffé test indicated that there was no room for significant improvement from one trial to the next for the subjects who studied this method. Therefore, it appears that the significant two-way interaction was also an experimental artifact due to a ceiling effect for the Pictorial Guided Practice group, and need not affect the interpretation of main effects.

Perhaps, the most important finding of this study is that the experimental method of forming procedural training material is considerably superior to the traditional narrative method for retention of the performance task, both immediately and after one week's time. The difference is so marked that even low aptitude subjects performed better using the experimental text than high aptitude subjects using the standard materials. Furthermore, the amount of study time required by each method is comparable. The experimental text required on the average 67.5 minutes to study one-time through. The traditional narrative text required 60 minutes. Many of the students using the Pictorial Guided Practice handbook said they liked using the text and thought it was more easy to understand than the narrative text they were currently using. These results provide a strong endorsement for the use of a pictorial/redundant print programmed instruction format for teaching procedural skills in technical settings. Since sixty percent of Navy training is of a "how-to-do" or procedural nature (Stitch, 1977) any instructional technique which results in better performance, reduced training time or both, deserves serious consideration.

One possible drawback, however, is that the experimental format is more elaborate and more expensive to produce than the narrative text using standard publishing techniques. Braby, Parrish, Guitard and Aagard (1978) have demonstrated the usefulness of a general purpose computer to aid in the authoring of instructional materials for teaching Morse Code. In their study, the generic instructional

formats were stored in the computer system and information about the Morse Code symbols were entered into a data base. Then, computer routines merged the information to be learned with the generic formats and automatically organized and printed complete learning packages (Guitard, 1978). Such an approach has potential to reduce the long-term costs and the amount of time it takes to produce such elaborate training materials.

The feasibility of computer-aided authoring the procedure learning formats evaluated in this study is currently being investigated by the U.S. Navy Training Analysis and Evaluation Group at Orlando, Florida. Their efforts will determine if the Pictorial Guided Practice format is in fact a cost-effective alternative to a traditional narrative textbook for teaching procedural tasks.

Although no final recommendations can yet be made, the results of this study do justify the preparation of training materials for complex procedural tasks using the experimental format, and their evaluation in operational settings.

Appendix A

PROBE CALIBRATION PROCEDURE

Tektronix 545B Oscilloscope

Standard Narrative

Operation

In this lesson, you will study and learn about the names of the oscilloscope control knobs and what they do. You will also learn how to calibrate a 10X test probe used in conjunction with the oscilloscope.

ENABLING OBJECTIVE(S):

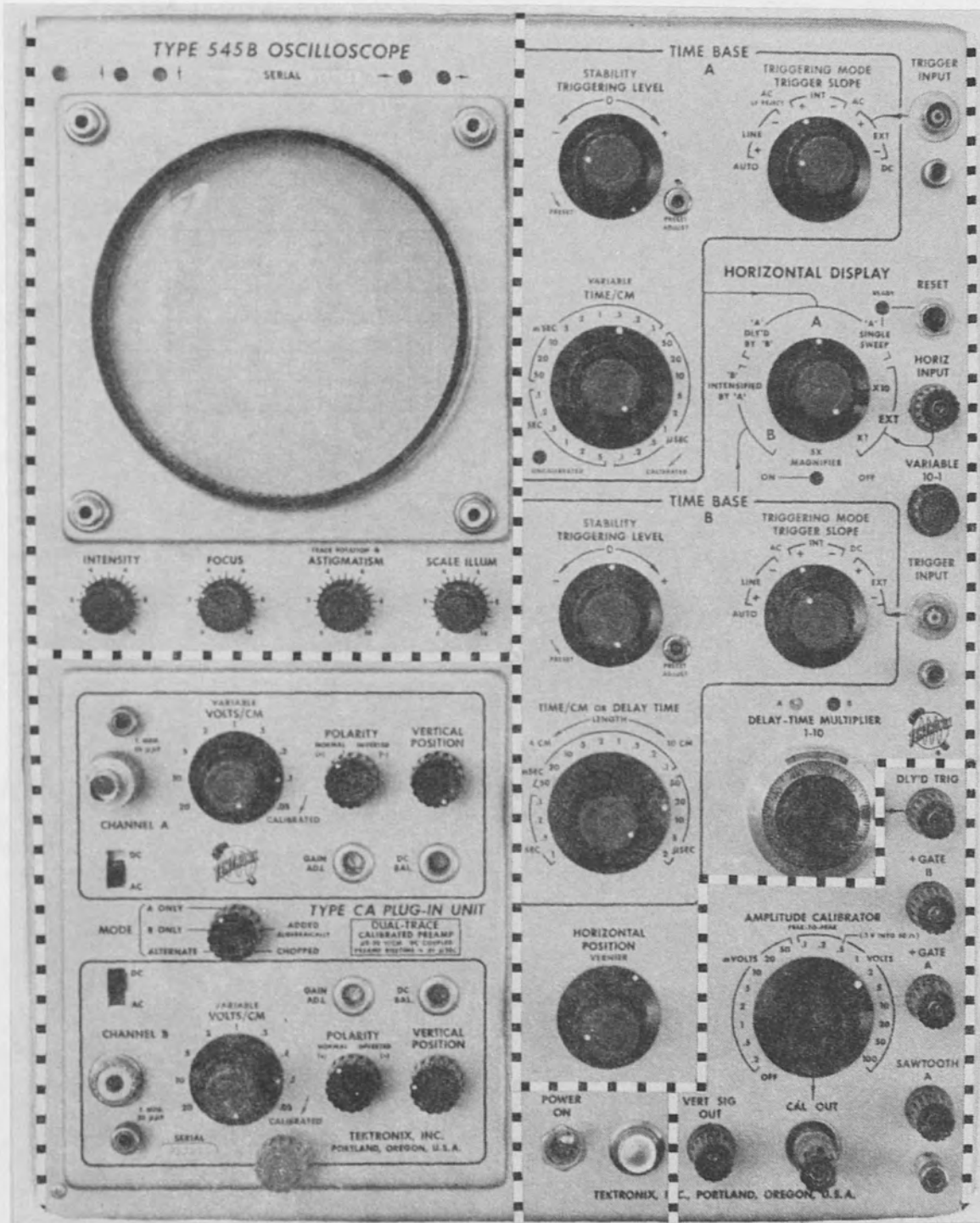
When the student completes this lesson, he will be able to:

1. IDENTIFY the function and effect of the ON-OFF, Focus, Intensity, Scale Illumination, Astigmatism, Horizontal Position, Volts/Cm, Variable Volts/Cm, Vertical Position, AC/DC coupling, Amplitude Calibrator, Trigger Slope, Triggering Mode, and Mode controls with respect to an oscilloscope representation by matching the front panel controls to their functions and to their effects.
2. CALIBRATE a 10X probe, given an uncalibrated 10X probe and oscilloscope.
3. IDENTIFY the steps in the procedure to calibrate a 10X probe.

SUMMARY
LESSON I

The most versatile piece of test equipment available to the technician is the oscilloscope. The oscilloscope enables the technician to see what is actually taking place in a circuit by graphically displaying voltage amplitude, wave shape, phase, and frequency.

The basic controls and their functions are the same for most oscilloscopes, the only difference is the way they are named.



Summary

Lesson I

The following is a brief list of the controls for the oscilloscope shown in Figure 1 and their functions.

On/Off (power) switch energizes the oscilloscope and controls all functions of the oscilloscope by controlling the power.

INTENSITY control varies the intensity of the line trace from very bright to so dim it can't be seen.

If you have a blurred or fuzzy line trace the FOCUS and ASTIGMATISM controls will remedy the problem. The FOCUS control varies the concentration of the electron beam to give a sharply defined trace. The ASTIGMATISM control varies the point at which the electron beam converges to improve trace definition.

The brightness of the graticules or scale on an oscilloscope is controlled by the SCALE ILLUMINATION control.

The horizontal controls consist of the HORIZONTAL DISPLAY, 5X MAGNIFIER, TIME/CM, VARIABLE TIME/CM, and the HORIZONTAL POSITION controls.

The HORIZONTAL DISPLAY selector determines what time base (A or B) will be used. It also determines what modes the time base will be used in.

The 5X MAGNIFIER switch, when set to the ON position, causes the horizontal portion of the display to be magnified five times wider than normal.

The TIME/CM control essentially governs the speed at which the sweep moves across the CRT screen.

The VARIABLE TIME/CM switch, when at "calibrated" serves to hold the value set by the TIME/CM selector constant so that the speed at which the sweep moves across the screen does not fluctuate.

The HORIZONTAL POSITION control does nothing more than move the sweep from left to right. It also has a coarse and fine tuning feature.

The vertical section is comprised of the VOLTS/CM, VARIABLE VOLTS/CM, AMPLITUDE CALIBRATOR, and the VERTICAL POSITION controls.

The VOLTS/CM selector states how many volts are represented by each centimeter on the vertical portion of the CRT scale. It essentially governs the size of the displayed waveform.

The VARIABLE VOLTS/CM, when "calibrated" keeps the value set by the VOLTS/CM selector constant so that the size of the displayed waveform does not fluctuate.

The AMPLITUDE CALIBRATOR determines the peak-to-peak voltage of the square wave available at the CAL OUT connector.

The VERTICAL POSITION control moves the presentation up and down on the screen.

In order to have a stable sweep the oscilloscope must be synchronized with a trigger.

The TRIGGER SLOPE control provides triggers from these places:

The INT position gives an internal trigger from the oscilloscope itself.

The EXT position makes provisions for connecting an external signal of your choice to the oscilloscope.

The LINE position provides a 60 Hz trigger to the oscilloscope.

The +/- for each source determines if the waveform will trigger on the positive or negative portion of a signal.

The TRIGGERING MODE determines what part of the triggering signal will start the sweep.

The MODE selector determines in what form the waveform will be displayed on the CRT.

The AC/DC coupling switch can be used to block out the DC portion of the input signal.

A method of connecting the signal being measured to the oscilloscope is needed. For this purpose a test probe is used, more notable a 10X probe. The 10X probe attenuates (decreases) the signal by a factor of 10; therefore, you must multiply by 10 to get a true voltage measurement. The 10X probe has an internal adjustable capacitor for impedance matching the probe to the oscilloscope. This matching is called calibration and must be checked daily.

NARRATIVE LESSON I

Operation

The most versatile piece of test equipment available to the technician is the oscilloscope. The oscilloscope enable the technician to graphically display voltage amplitude, shape, phase, and frequency of a waveform. All this means is, that you can see a picture of what is actually taking place in the circuit that is being checked. The oscilloscope, with the addition of various accessories, can do a number of other more advanced operations.

Let's find out how the oscilloscope does all of this.

The display screen is the front or face of a cathode ray tube, commonly abbreviated as CRT. In operation, there is a spot of light on this screen called the "trace spot". This trace spot is moved from left to right across the screen by electronic circuits in the oscilloscope calle the "horizontal sweep circuits". The time it takes the trace spot to move form left to right across the screen can be varied. These changes are precisely calibrated so that the speed of horizontal movement represents an exact amount of time. If the trace spot is moved across the fast enough, it will appear to become a solid line. This line is commonly called a "line trace" or "sweep". The lenght of this line trace (maximum left to right movement) is predetermined by internal circuitry. This line trace or sweep is the heart of the oscilloscope. Without the trace, it would be impossible to display anything on the oscilloscope.

The trace spot can also be deflected vertically. This deflection is created by the signal being measured. The size of the signal being displayed can be amplified or reduced so the signal voltage will cause the trace spot to be deflected a specific distance on the face of the CRT

Conbining the vertical movement of the trace spot, caused by the signal being measured, with the left to right movement of the trace spot, caused by the internal horizontal sweep circuitry, will produce a graphic display. This display is commonly called the "waveform" of the signal. This graphic waveform is plotted against time in the horizontal axis, and amplitude in the vertical axis.

This is a very basic explanation of how an oscilloscope does what it does.

The oscilloscope you will be using is a "Tektronix 545B" With the exception of the physical placemeht of controls and control names, the information contained in this lesson can be applied to any

oscilloscope.

Now let's discuss the basic controls of the oscilloscope. Each control on the oscilloscope has a definite effect on the waveform presented on the CRT. As the basic controls are discussed in this lesson, the control name used in this lesson will be on the oscilloscope you will be using, with other common names for the same controls in parenthesis. In the job program following this lesson, you will get "hands on" experience operating the various controls.

ON/OFF

The most important control on the oscilloscope is the ON/OFF (power) switch. This switch is used to energize or turn the oscilloscope on. It controls every function of the oscilloscope, either directly or indirectly by virtue of controlling whether or not any power is applied to the oscilloscope.

INTENSITY

The INTENSITY control of the oscilloscope varies the intensity or brightness of the line trace. Normally turning the INTENSITY control in a clockwise direction will increase the intensity of the line trace and turning it counterclockwise will decrease the intensity. If turned completely counterclockwise often a point will be reached where the trace can no longer be seen. If you are using an oscilloscope and can't get a line trace, there is a good possibility that the INTENSITY control has been turned down.

FOCUS AND ASTIGMATISM

After the intensity is set to the desired level, you are going to want a sharp, clear, well defined line trace. If the line trace is blurred or fuzzy, there are two controls that remedy this problem. The FOCUS control varies the concentration of the electron beam to give a sharply defined trace, and the ASTIGMATISM control varies the point at which the electron beam converges to improve trace definition (clarity). Usually, the trace will be set at its clearest point with the FOCUS and ASTIGMATISM controls around a mid-range setting. The FOCUS, and ASTIGMATISM controls interact when being adjusted. This means that when you adjust one it might effect the other control necessitating the re-adjustment of the other.

SCALE ILLUMINATION

Most oscilloscopes have a scale or graticule on the face of the CRT. The waveforms are plotted against this graticule to make voltage and frequency measurements. In order to see this graticule clearly it must be illuminated. The scale ILLUM. control varies the amount of light on the scale. Turning it counterclockwise will decrease the illumination and turning it clockwise will increase the illumination.

There are 5 basic horizontal controls consisting of the HORIZONTAL DISPLAY, 5X MAGNIFIER, TIME/CM, VARIABLE TIME/CM, and the HORIZONTAL POSITION controls.

HORIZONTAL DISPLAY

The HORIZONTAL DISPLAY selector determines how the time bases will be displayed on the CRT. In the "A" position it allows only TIME BASE A to appear on the CRT. In the "B" position only TIME BASE B will appear on the CRT. The other positions are delayed functions and single sweep functions.

5X MAGNIFIER

The 5X MAGNIFIER control, when activated, will multiply the horizontal sweep by a preset factor. On the oscilloscope you will be using this factor is 5 times. On other oscilloscopes this factor could be anywhere from 5-100 times. This function allows a waveform viewed on the oscilloscope to be magnified to a point that only a very small portion of the original signal covers the entire horizontal axis of the CRT.

TIME/CM

The TIME/CM switch will determine the frequency (speed) that the trace spot moves across the CRT. As you decrease the time per centimeter with the TIME/CM switch, the trace spot moves faster and becomes a solid line or trace line. If you increase the time per centimeter with the TIME/CM switch, the trace spot moves across the face of the CRT more slowly. The TIME/CM switch is usually calibrated in seconds, milliseconds, and microseconds. Each position will represent a preset amount of time it takes the line trace to move one division of the graticle from left to right. A crowded presentation can be spread out by decreasing the TIME/CM. A presentation that expands beyond the limits of the CRT can be contracted for easier viewing by increasing the TIME/CM.

VARIABLE TIME/CM

The VARIABLE TIME/CM, when in the "calibrated" position, serves to keep the sweep rate value set by the TIME/CM selector constant. If the switch is in the "uncalibrated" position, the sweep rate specified by the TIME/CM switch can be slowed by a factor of at least 2.5X. When the switch is in the "uncalibrated" position a lamp comes on to let you know.

HORIZONTAL POSITION

Suppose, that while using the oscilloscope you find the presentation is positioned to the left of the center of the CRT. The position can be changed by simply adjusting the HORIZONTAL POSITION control in a clockwise direction until the presentation is centered on the CRT. Counterclockwise movement of the HORIZONTAL POSITION control moves the trace to the left. The HORIZONTAL POSITION control governs only the horizontal movement of the line trace. This particular control also has a course tuning (outer black knob) and a fine tuning (inner red knob) feature.

VOLTS/CM

Now that the horizontal controls have been covered, let's discuss the vertical controls. The VOLTS/CM switch adjusts the vertical amplitude of the signal viewed on the CRT. The VOLTS/CM switch is a rotary switch with preset volts per centimeter divisions. It is usually calibrated in seconds, milliseconds, and microseconds. If your signal is too small vertically to be seen clearly, turning the VOLTS/CM switch clockwise will increase its size. If the vertical signal is too large to see the entire signal on the CRT, turn the VOLTS/CM switch counterclockwise to decrease the size of the signal.

VARIABLE VOLTS/CM

The VARIABLE VOLTS/CM control works much in the same way the VARIABLE TIME/CM switch does. If in the "calibrated" position, the value set by the VOLTS/CM will remain constant. If in the "uncalibrated" position, the vertical amplitude of the displayed waveform can be varied.

VERTICAL POSITION

Suppose the vertical position of the trace were such that you couldn't see the entire signal. To remedy this situation, there is a control called the VERTICAL POSITION control. This control moves the trace position up and down on the CRT. Turning the control clockwise will move the trace up and turning it counterclockwise will move it down.

AC/DC

The AC/DC switch determines what type of coupling is used on the input to the vertical section. In the DC position, the vertical input is directly coupled allowing a DC signal to be passed to the vertical section. When viewed on the face of the CRT, a DC signal is a upward or downward shift of the trace. An upward shift indicates a positive voltage and a downward shift indicates a negative

AC LF REF

(Time Base A only) attenuates trigger signal frequencies below about 30 kHz, decreasing their effect upon the trigger circuit.

AC

Blocks the DC componte of the triggering signal and allows triggering to take place only on the changing protion of the signal. For best triggering at high frequencies use an AC coupling position.

DC

Permits triggering on both high and low frequency signals. For signals below 30 Hz use the DC position.

AMPLITUDE CALIBRATOR

The AMPLITUDE CALIBRATOR sets-up the peak-to-peak voltage of the square wave that is available ant the oscilloscope CAL OUT connector.

MODE

The MODE selector switch determines how the signal will be displayed on the CRT. For instance, by selecting A ONLY it tells the equipment to only display the waveform set-up from TIME BASE A.

voltage. With no signal input the trace will be at the center line of the graticle. With a +20 volt DC signal input, the trace will shift upward to a point equivalent to +20 volts. In the AC position the input is capacitively coupled blocking all DC to the vertical section. With the AC switch in this position, there is no shift in the trace even with a DC signal present. The signal viewed will remain on the center line of the scale.

TRIGGER SLOPE

Normally there are 3 sources available for use as synchronizing signals. The TRIGGER SLOPE control determines which of these signals is being used.

INT

Selecting the INT position applies an internally generated signal to the sweep to be used to synchronize the waveform.

EXT

The EXT position allows an external signal to be applied to the sweep. This external signal can be from whatever source provides the correct frequency and type of signal necessary to synchronize the sweep. Normally this external signal comes from the equipment being tested.

LINE

The LINE position provides a synchronizing signal of 60 Hz. This signal is used with input signals of 60 Hz or any harmonic (multiple) of 60 Hz (120 Hz, 240 Hz).

The + and - for each source determines on which portion of the signal + or -, the waveform will begin.

TRIGGERING MODE

The TRIGGERING MODE control determines what part of the triggering signal will start the waveform display.

AUTO

Permits normal triggering on simple waveforms with repetition rates higher than about 50 Hz with no trigger signal. At a lower repetition rate the trigger circuit goes runs at approximately 40 Hz and triggers the time base at this rate, providing a reference trace.

JOB PROGRAM

LESSON I

Introduction

The oscilloscope is a rugged piece of equipment. Aside from mechanical damage (dropping, forcing controls and other abuses) an oscilloscope is subject to "burning" the screen (explained in text). The oscilloscope will accept input voltage to a maximum of 600 volts peak without damage.

This job program is designed to give you "hands on" experience in using the oscilloscope. Don't be afraid to experiment with the controls, just keep in mind to experiment carefully.

Very high voltage exists inside the case of the oscilloscope.
DO NOT REMOVE THE COVER.

ENABLING OBJECTIVES:

When the student completes this lesson, he will be able to:

1. CALIBRATE a 10X probe, given an uncalibrated 10X probe and oscilloscope.
2. IDENTIFY the steps in the procedure used to calibrate a 10X probe.

EQUIPMENT AND MATERIALS

1. Oscilloscope
2. BNC cable
3. Probe

PROCEDURE

In the first part of this section, you will learn how to energize the oscilloscope and what the CRT controls do. In Lesson I you learned the basic controls associated with an oscilloscope. These new controls will be discussed as they are encountered in the job program. Perform the following steps on the Tektronix 545B oscilloscope.

1. Make sure power is OFF by pushing switch down. The power must be off so that the oscilloscope is not damaged when it is plugged-in.

2. Attach power cords in teh bask of the oscilloscope and to the wall outlet.
3. Set the CRT controls (the horizontal row of four knobs located beneath the CRT).
 - a. INTENSITY to midrange
 - b. FOCUS to midrange
 - c. SCALE ILLUM. to midrange

CAUTION: The scree can be "burned" producing a dark dead spot on the screen. "Burning" is a result of having the trace spot in the same position for a period of time with the INTENSITY turned up.

To preylent "burning" the screen, follow these rules:

- a. Ensure the INTENSITY control is not beyond midrange.
 - b. Turn the INTENSITY control clockwise only enough so that the trace can be easily see.
4. Energize the oscillocope by pushing the POWER switch up. When this is done the light ot the right of the switch and the ventila-tion fan comes on.
5. Set THE MODE selector switch (located at the center of the Type CA plug-in Unit) to A ONLY.

The next group of controls you will set are the Time Base A TRIGGER-ING MODE and the TRIGGER SLOPE. These controls determine when the trace will begin to sweep across teh screen. This action is accomp-lished by "holding" the trace spot at the left of the screen until it is told to "go" by a strating signal called a trigger.

6. Set the Time Base A TRIGGERING MODE switch (inner red knob) to AUTO by turning the know completly counterclockwise until it stops. The AUTO mode electronically sets the trigger lefel near zero, elim-inating the need to set the TRIGGER LEVEL control that is located just left of the TRIGGERING MODE and TRIGGER SLOPE knobs.
7. Set the TRIGGER SLOPE switch (outer black knob) to +INT. This control determines the source of the starting trigger. It tells the oscilloscope that the signal will be generated from its own circuitry (INT means internal). The "+" tells the oscilloscope to start the trace on the positive going portion of the triggering signal.

The next group of knobs you will set are horizontal sweep controls.

8. Set the HORIZONTAL DISPLAY switch (outer black knob) to A. When you do this a trace should be visible on the CRT.

9. Set the 5X MAGNIFIER switch (inner red knob on the Horizontal Display control) to OFF by turning it completely counterclockwise.
10. Set the Time Base A TIME/CM switch (outer black knob) located to the left of the Horizontal Display control, to .5 mSEC.

Now let's do some figuring. The time per centimeter switch (TIME/CM) is in the .5 mSEC position. How long will it take the trace spot to move one centimeter on the screen?

(Ans.) .5 milliseconds.

How long will it take to sweep from the left to the right side of the scale:

(Ans.) $.5 \text{ mSEC} \times 10 \text{ centimeters} = 5 \text{ milliseconds}$

11. Set the VARIABLE TIME/CM switch (inner red knob) to CALIBRATED by turning it clockwise until it clicks and the light goes out. The VARIABLE TIME/CM control allows you to slow the sweep speed set by the TIME/CM selector by a factor of 2.5X. However, when it is in the CALIBRATED position the sweep rate set by the TIME/Cm knob will remain constant.

12. Illuminate scale on display surface by turning the SCALE ILLUM. knob, located just below the CRT, fully clockwise. Note the change in the scale brightness as you turn the knob.

13. Adjust the HORIZONTAL POSITION knob located above the POWER ON switch until the edge of the trace touches the left graticle of the screen.

14. Adjust the VERTICAL POSITION knob . located on the CHANNEL A portion of the Type CA Plug-in Unit, until the trace line is centered on the CRT scale.

15. Adjust the FOCUS and ASTIGMATISM controls. If you rotate the FOCUS control fully counterclockwise and then fully clockwise the trace will become larger and fuzzier as you move the control away from its center position. If you rotate the ASTIGMATISM control fully clockwise and then fully counterclockwise you can see that the controls interact, which means when you turn the FOCUS control the thickness of the trace may be affected, and when you turn the ASTIGMATISM control the sharpness may be affected. To compensate for this action, it may be necessary to adjust one control and then the other several times to get the trace set up properly.

16. Loc the probe line onto the CHANNEL A INPUT connector, located below the INTENSITY knob.

17. Set CHANNEL A AC/DC switch (located just below the CHANNEL A INPUT connector) to AC. When this switch is in the AC position the input signal goes through a capacitor which will block any DC voltage present on the signal. If you are not specifically concerned with DC voltage, it is usually better to use the AC position.

Next you will set the various vertical controls.

18. Set the CHANNEL A VOLTS/CM switch to .1 volts and its VARIABLE control to "CALIBRATED" (fully clockwise).

Multiply the number of centimeters by the VOLTS/CM selector setting. Your answer is the peak-to-peak voltage of the waveform.

19. Set the AMPLITUDE CALIBRATOR (located to the right of the HORIZONTAL POSITION control) to 2 volts.

20. Insert the probe tip into the CAL OUT connector located just below the AMPLITUDE CALIBRATOR and look at the waveform displayed on the CRT. The waveform will have a negative and a positive peak exactly 2 centimeters apart, and, if the probe is calibrated, the peaks will be absolutely flat. See Figure 1.



Figure 1

If the probe is over compensated the sweep will have peaks on the leading edge. See Figure 2.

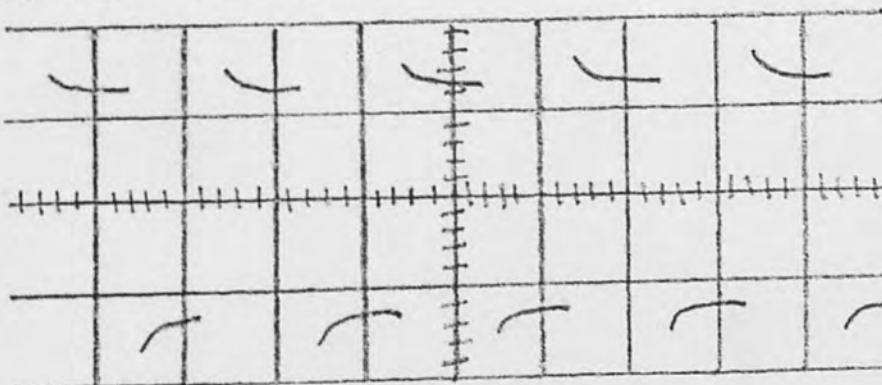


Figure 2

If the probe is under compensated the leading edge will be rounded. See Figure 3.

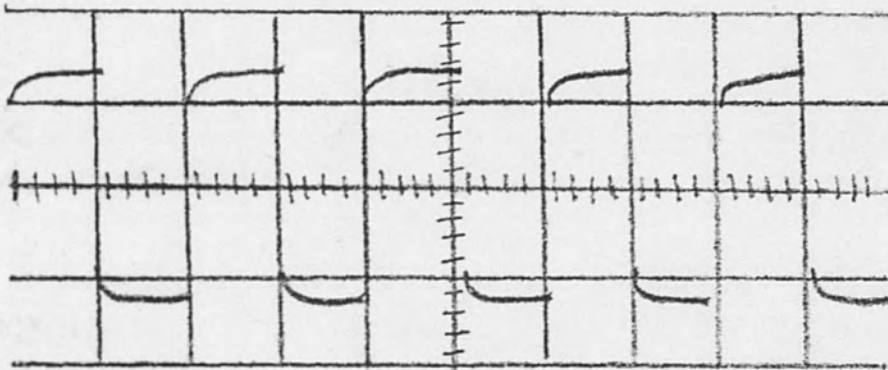


Figure 3

To calibrate the probe, hold the adjusting collar with the right hand, loosen the locking sleeve about one quarter turn with the left hand. While watching the trace on the CRT, turn the adjusting collar until the peaks are absolutely flat. Now, slowly turn the locking sleeve until it is "finger-tight" Look at the waveform to ensure the trace on the CRT hasn't changed while locking the probe. See Figure 4.

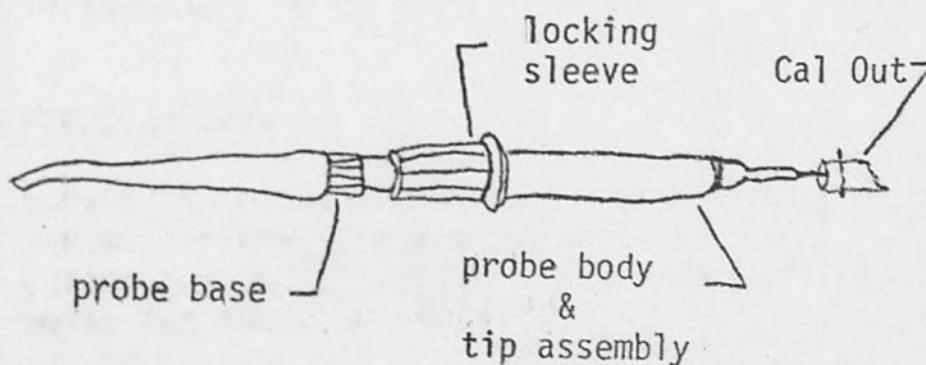


Figure 4.

PROGRESS CHECK
LESSON I

Answer all the questions in this section and check your responses with the answer sheet on page 21. If you incorrectly answered a few of the progress check questions, the correct answer page will refer you to the appropriate pages so you can restudy the parts of this lesson you are having difficulty with.

1. An oscilloscope lets you see what is taking place in a circuit by
 - a. X-raying the circuit under test and producing a photographic display of the signal.
 - b. graphically displaying voltage amplitude, wave shape, phase and frequency of waveforms.
 - c. graphically displaying circuit current and resistance.
 - d. analyzing the input and output of the circuit and producing a photograph of the circuit action.

2. The ON/OFF switch
 - a. varies the brightness of the sweep.
 - b. turns power on or off.
 - c. varies the illumination of the graph on the CRT face.
 - d. horizontally positions the trace.

3. The FOCUS control
 - a. varies the point where the electron beam converges.
 - b. varies the brightness of the sweep.
 - c. varies the concentration of the electron beam.
 - d. moves the sweep up and down.

4. The INTENSITY control
 - a. varies the brightness of the sweep.
 - b. turns the power on and off.
 - c. illuminates the graph on the CRT face.
 - d. varies the concentration of the electron beam.

5. The SCALE ILLUM. control

- a. turns the power on or off.
- b. varies the brightness of the sweep.
- c. adjusts the oscilloscope for a stable presentation.
- d. varies the illumination on the graph on the CRT face.

6. The ASTIGMATISM control

- a. varies the concentration of the electron beam.
- b. turns the power on and off.
- c. varies the point where the electron beam converges.
- d. magnifies the horizontal sweep by a preset factor.

7. The HORIZONTAL DISPLAY control

- a. magnifies the horizontal sweep by a preset factor.
- b. determines how the time bases will be displayed on the CRT.
- c. lengthens or shortens the sweep with respect to time.
- d. determines the point at which the sweep triggers.

8. The 5X MAGNIFIER control

- a. magnifies the horizontal sweep by a preset factor.
- b. moves the entire sweep horizontally.
- c. varies the amplitude of the vertical signal.
- d. changes the coupling of the vertical input signal.

9. The TIME/CM control

- a. moves the entire sweep horizontally.
- b. magnifies the horizontal sweep by a preset factor.
- c. picks the source of the trigger signal for synchronization
- d. lengthens or shortens the sweep with respect to time.

10. The HORIZONTAL POSITION control

- a. moves the entire sweep up or down.
- b. moves the entire sweep horizontally.
- c. determines the point at which the sweep is triggered.
- d. magnifies the sweep by a preset factor.

ANSWER SHEET
FOR
PROGRESS CHECK
LESSON I

<u>Question No.</u>	<u>Correct Answer</u>	<u>Reference Page</u>
1	b	6
2	b	7
3	c	7
4	a	7
5	d	7
6	c	7
7	b	7
8	a	8
9	d	8
10	b	8

Appendix B

PROBE CALIBRATION PROCEDURE

Tektronix 545B Oscilloscope

Pictorial Only

INTRODUCTION

Learning Objectives

When you complete this lesson you will be able to:

1. Set-up a square wave on an oscilloscope
2. Calibrate a 10X probe.

Testing

A test will be given on a Tektronix 545B oscilloscope to see if you know how to calibrate a probe.

Why Learn This Procedure

The oscilloscope is use to test circuits, study wave-forms, measure voltage and current, and test amplifier responses. A properly tuned probe is necessary for accurate measurement.

Additional Resources Required

Tektronix 545B oscilloscope and power supply, BNC cable, and a 10X probe.

OVERVIEW

NOTE

Fold out page 116. Leave it out for the entire lesson.

Directions:

1. Look at the foldout. Notice that the oscilloscope is divided into 5 functional sections. Listed below are the sections and the general functions each is responsible for.

SectionsFunctions

Power

on/off power controls

Horizontal controls

determines the width and horizontal positioning of a displayed signal

Vertical controls

determines the height and vertical positioning of a displayed signal

Calibration and Output

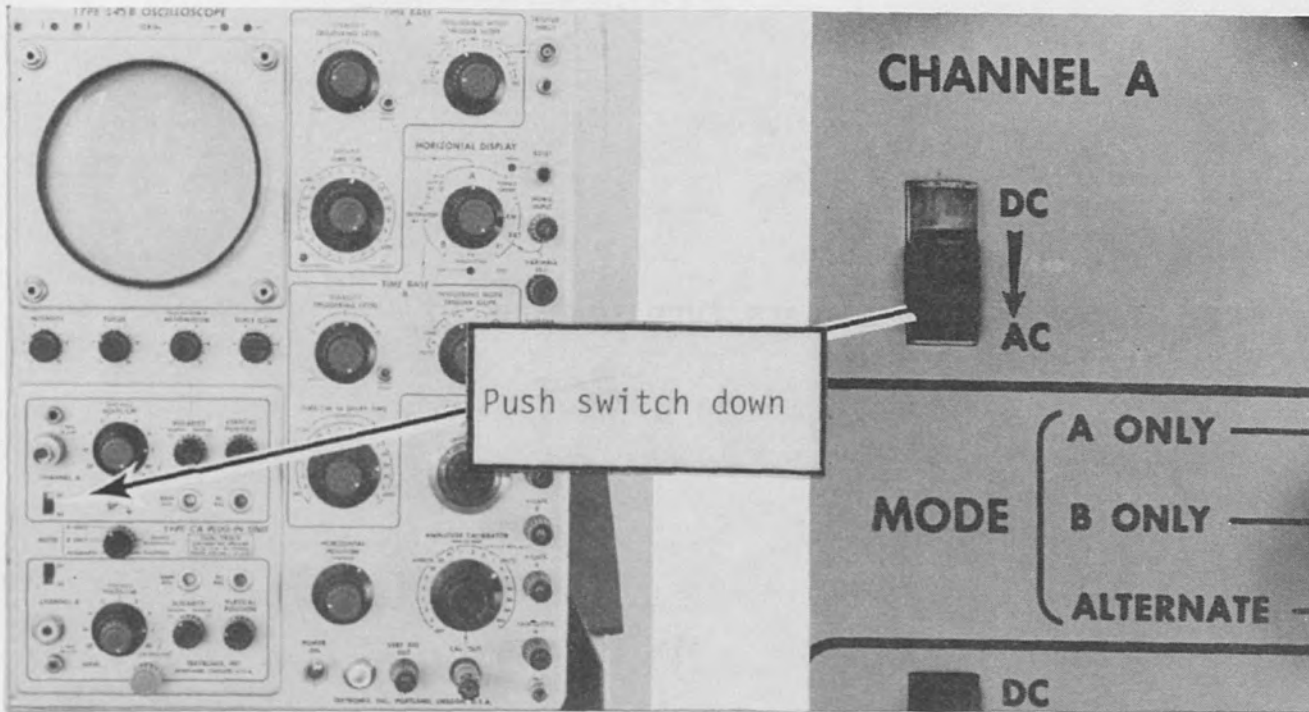
has output jacks which can be used to drive or synchronize other equipment

Display

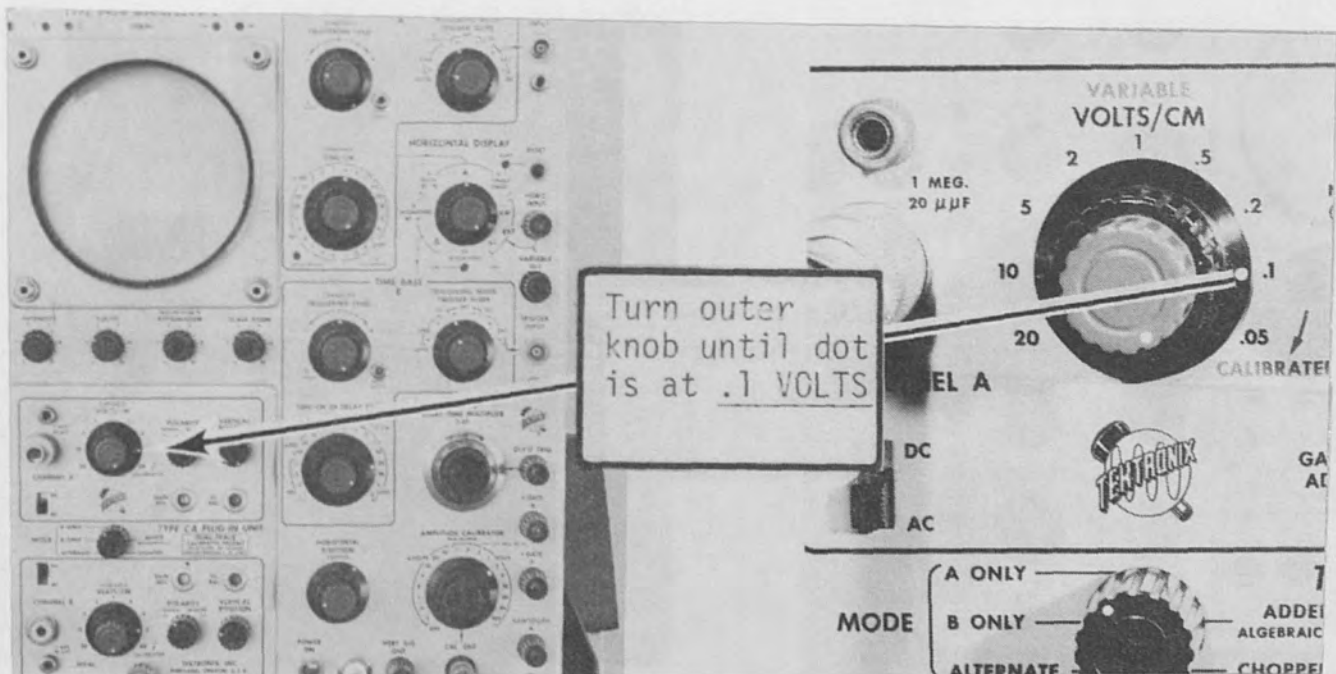
presents a picture of the test signal

2. The probe calibration procedure requires that the controls on these sections be set in a certain way. The rest of the lesson will show how to do this.

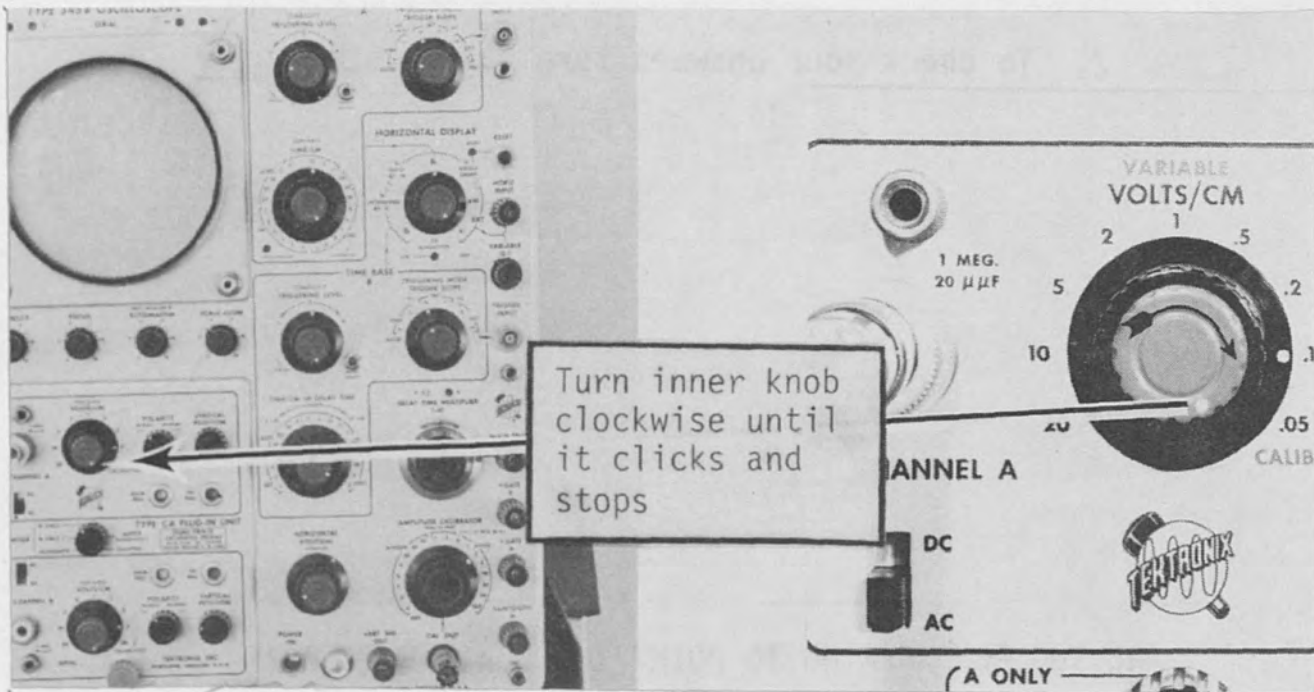
Step 16: Set CHANNEL A AC/DC coupling switch to AC.



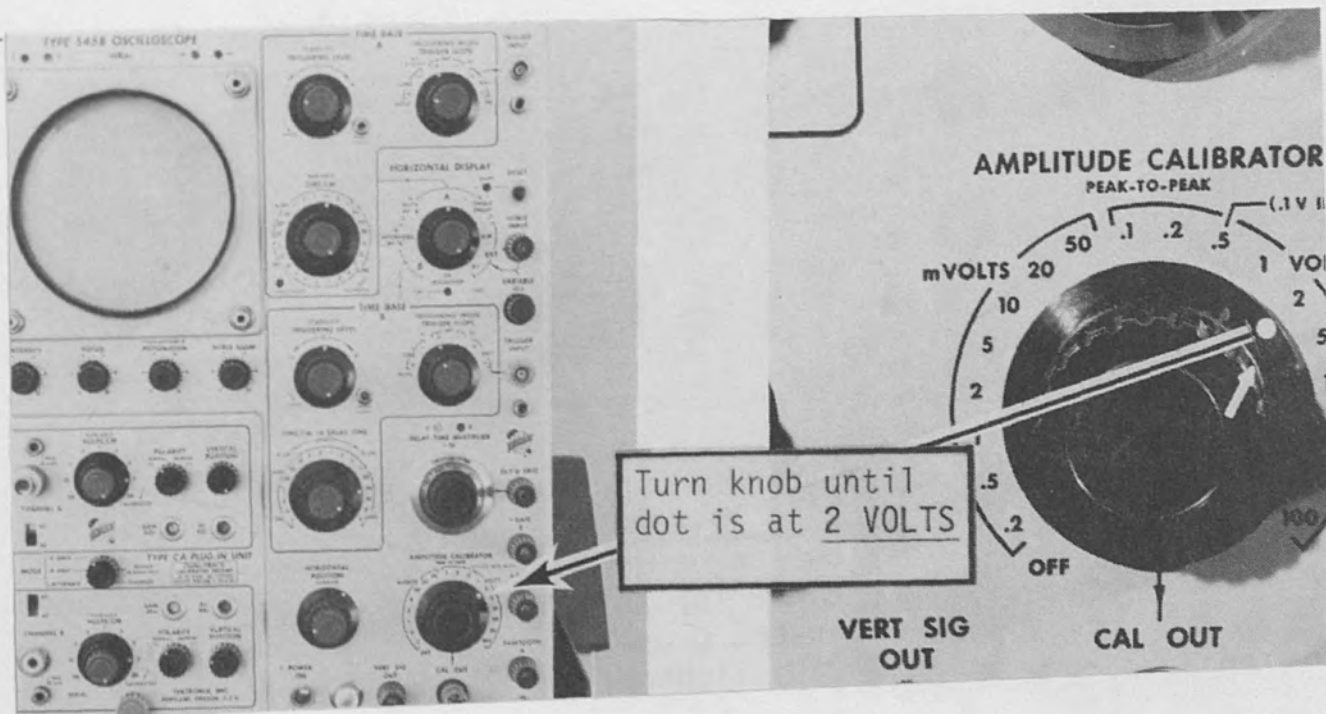
Step 17: Set CHANNEL A VOLTS/CM to .1 volts



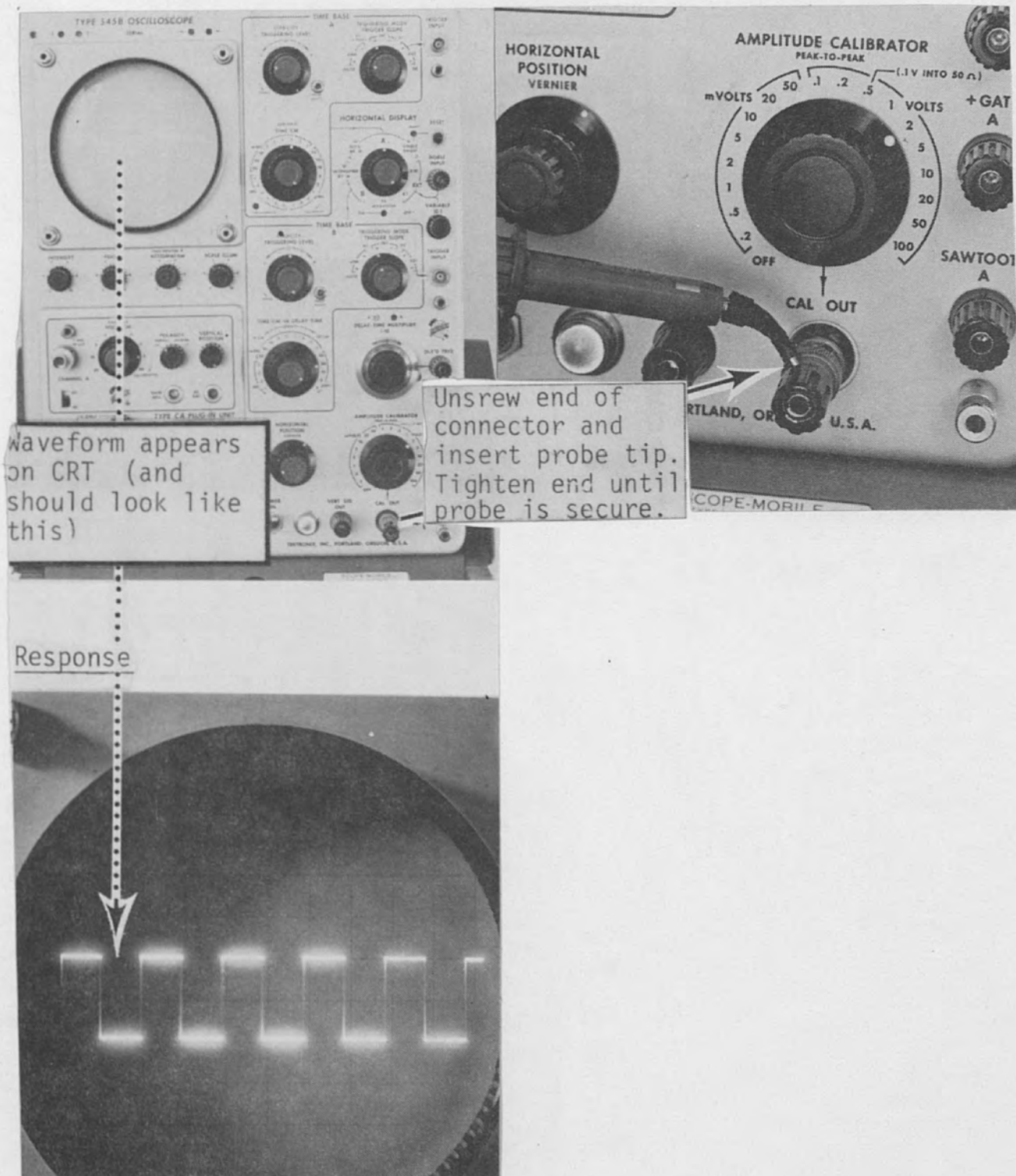
Step 18: Set VARIABLE VOLTS/CM switch to CALIBRATED.



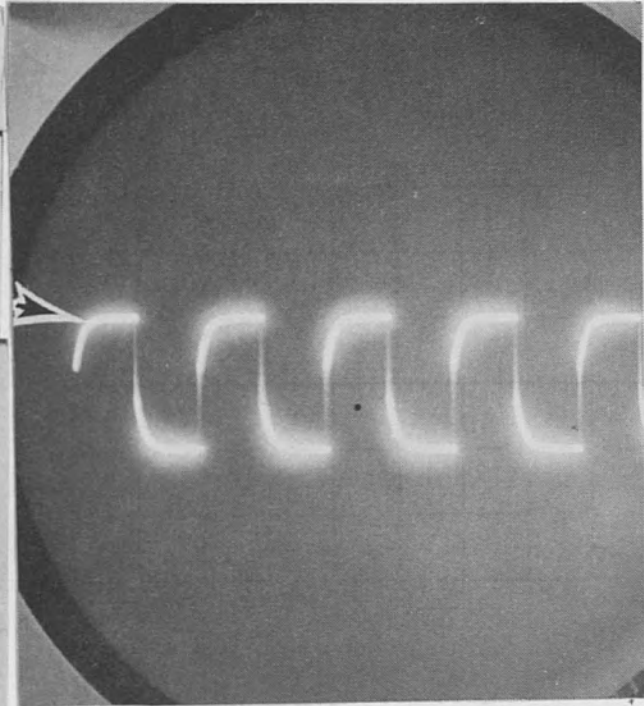
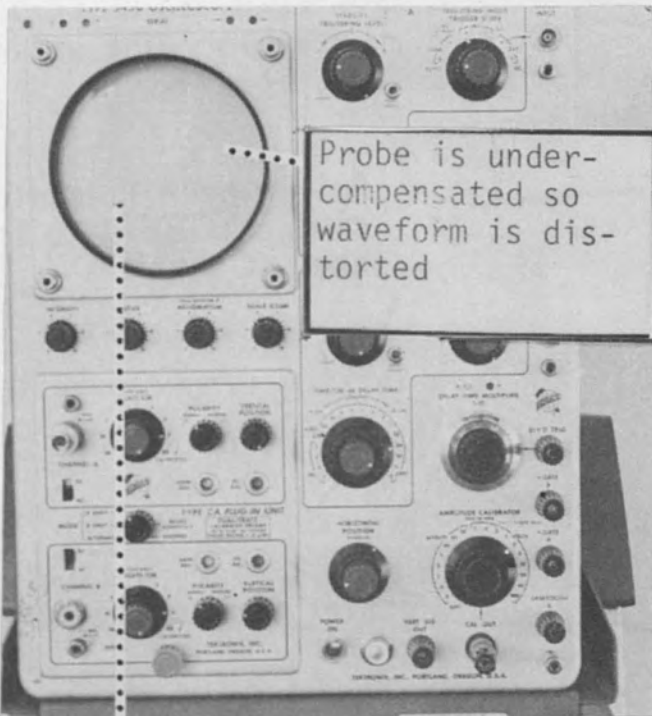
Step 19: Set AMPLITUDE CALIBRATOR to 2 volts.



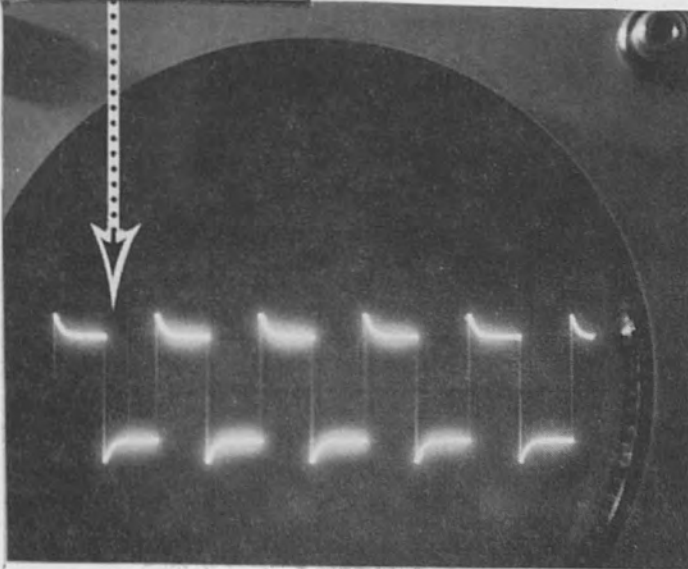
Step 20: Insert probe tip in the CAL OUT connector.



Step 20: continued

What can go wrong

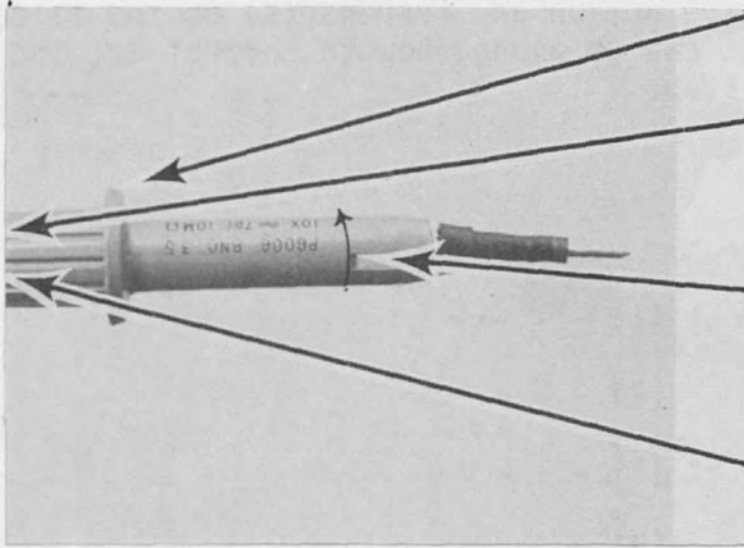
Probe is over-compensated so waveform is distorted



Step 20: continued

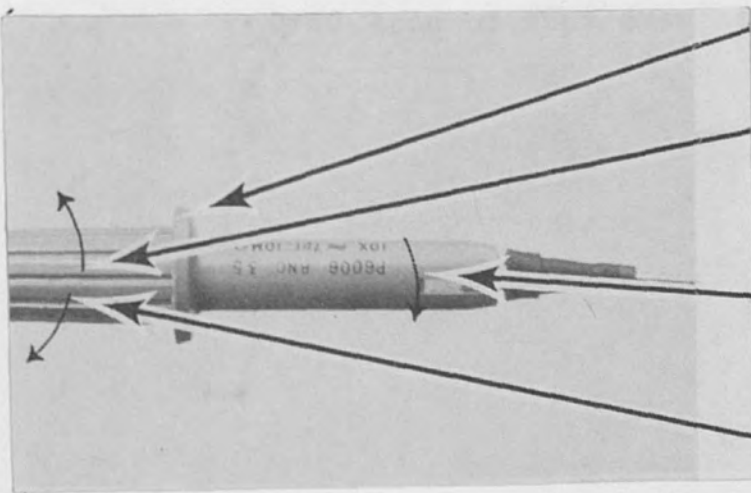
How To Correct It

Under compensated probe

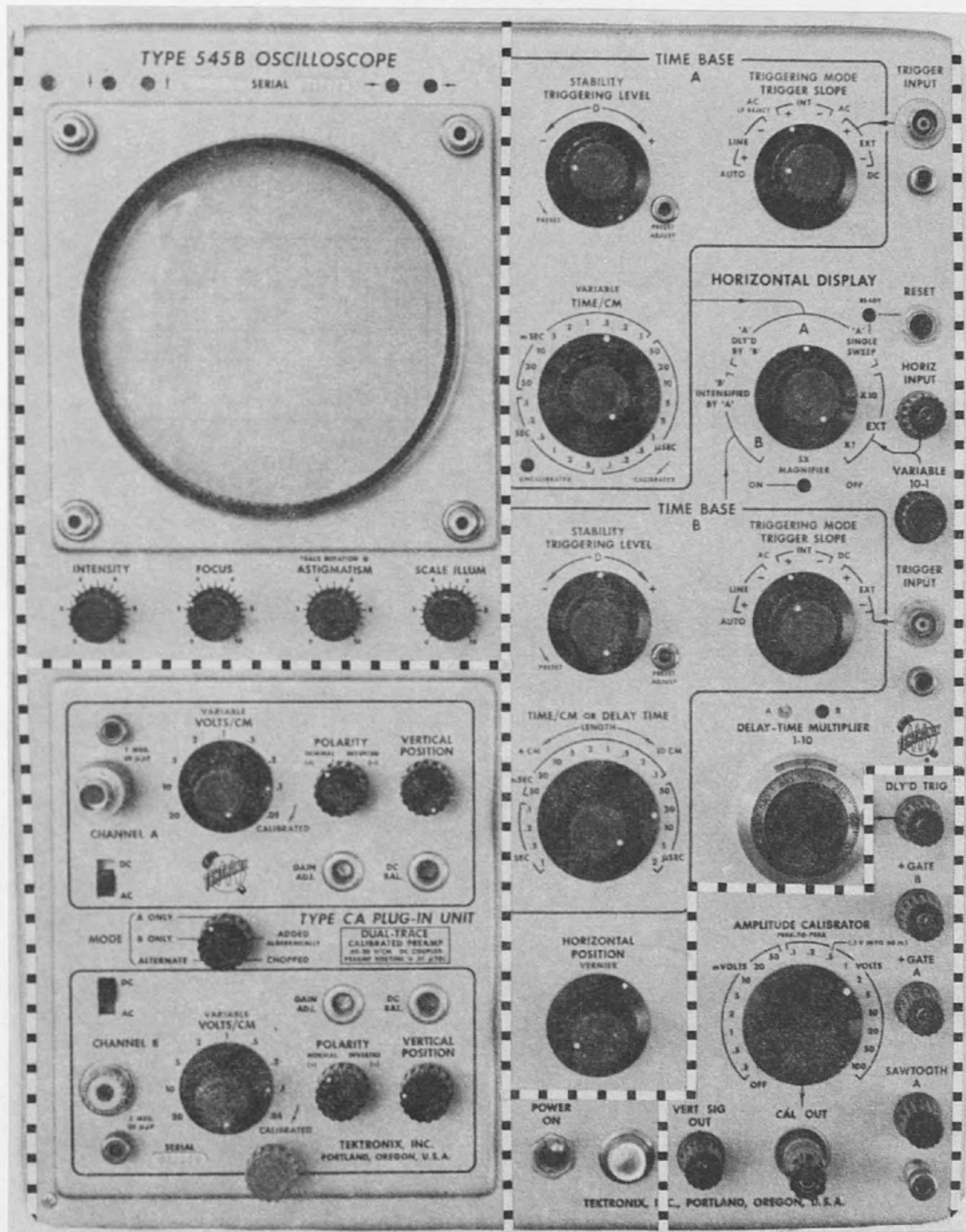


1. Hold center ring.
2. Turn locking ring counterclockwise until it moves freely.
3. Rotate tuning barrel clockwise until waveform is square.
4. Turn locking ring clockwise until secure.

Over compensated probe



1. Hold center ring.
2. Turn locking ring counterclockwise until it moves freely.
3. Rotate tuning barrel counterclockwise until waveform is square.
4. Turn locking ring clockwise until secure.



Appendix C

PROBE CALIBRATION PROCEDURE

Tektronix 545B Oscilloscope

Pictorial Guided Practice

INTRODUCTION

Learning Objectives

When you complete this lesson you will be able to:

1. Set-up a square wave on a oscilloscope
2. Calibrate a 10X probe

Testing

A test will be given on a Tektronix 545B oscilloscope to see if you know how to calibrate a probe.

Why Learn This Procedure

The oscilloscope is used to test circuits, study measure voltage and current, and test amplifier response. It does this by graphically displaying voltage amplitude, wave shape, phase, and frequency of waveforms on the CRT. A properly calibrated probe is necessary for an accurate graphic display.

Organization of Training Materials

For easier learning, the procedure is divided into four sections:

- | | |
|-------------|------------------|
| Section I | Turn Power ON |
| Section II | Get a Trace |
| Section III | Center the Trace |
| Section IV | Tune the Probe |

You will learn the steps in each section separately, then you will practice all the sections together.

Additional Resources Required

Tektronix 545B oscilloscope and power source, BNC cable, and a 10X probe.

OVERVIEW

NOTE

Fold out page 116. Leave it out for the entire lesson.

Directions:

1. Look at the foldout. Notice that the oscilloscope is divided into 5 functional sections. Listed below are the sections and the general functions each is responsible for.

<u>Sections</u>	<u>Functions</u>
Power	on/off power controls
Horizontal controls	determines the width and horizontal positioning of a displayed signal
Vertical controls	determines the height and vertical positioning of a displayed signal
Calibration and Output	has output jacks which can be used to drive or synchronize other equipment
Display	presents a picture of the test signal

2. The probe calibration procedure requires that the controls on these sections be set in a certain way. The rest of the lesson will show how to do this.

HOW TO USE TRAINING MATERIALS

Directions:

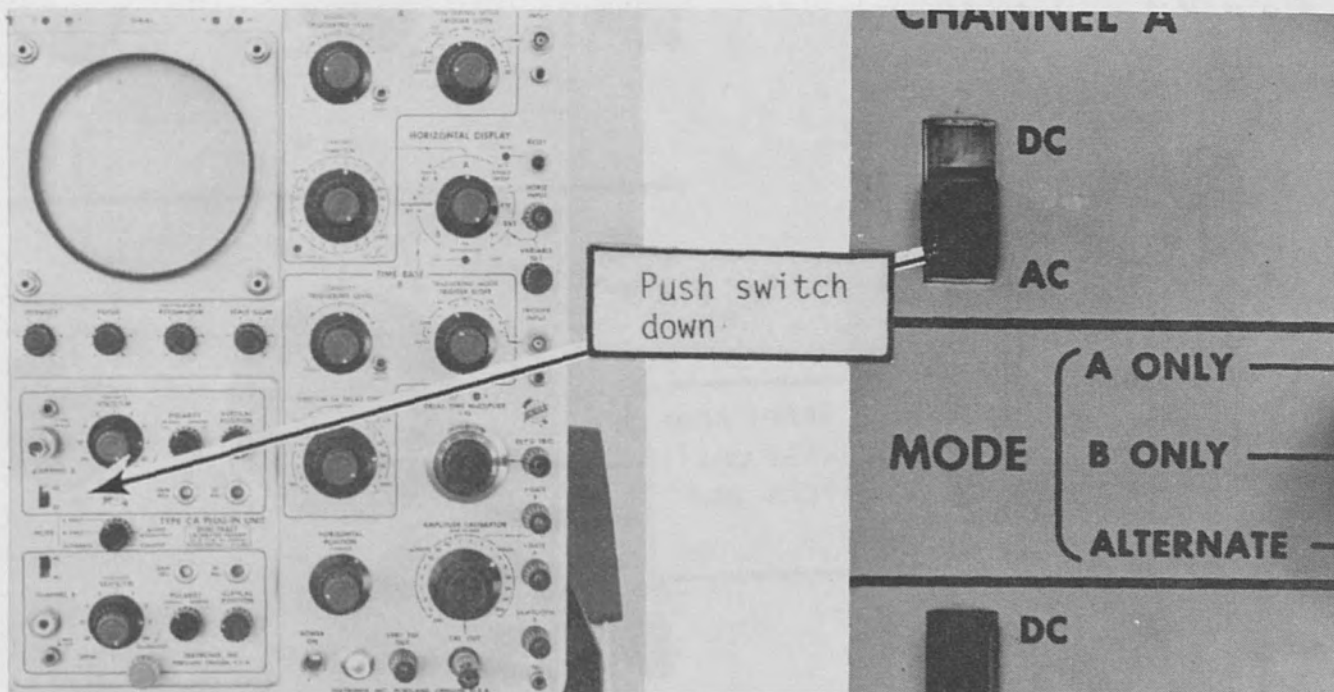
1. This lesson will be presented in a way that might be new to you. The following information will help.
 - a. Each step is presented in terms of the ACTION you will perform on the oscilloscope.
 - b. If the ACTION of a certain step makes the oscilloscope do something (display a trace line on the CRT) it will be presented under the heading of a RESPONSE.
 - c. If in a certain step there is a possibility that something can go wrong and would need troubleshooting, it will be presented under the headings of WHAT CAN GO WRONG and HOW TO CORRECT IT.
2. Take your time and learn each step correctly.
3. After each step you will be required to recall the ACTION and RESPONSE; and WHAT CAN GO WRONG and HOW TO CORRECT IT when necessary.
4. For best results, follow all instructions.

TRAINING Section IV - Tune the probe

Step 16: Set CHANNEL A coupling switch to AC

Purpose: In this procedure only AC signals need to be displayed

ACTION



CHECK YOUR MEMORY

Directions:

1. Point through the action and response(s) on the foldout and recall the note for this step.

Action _____

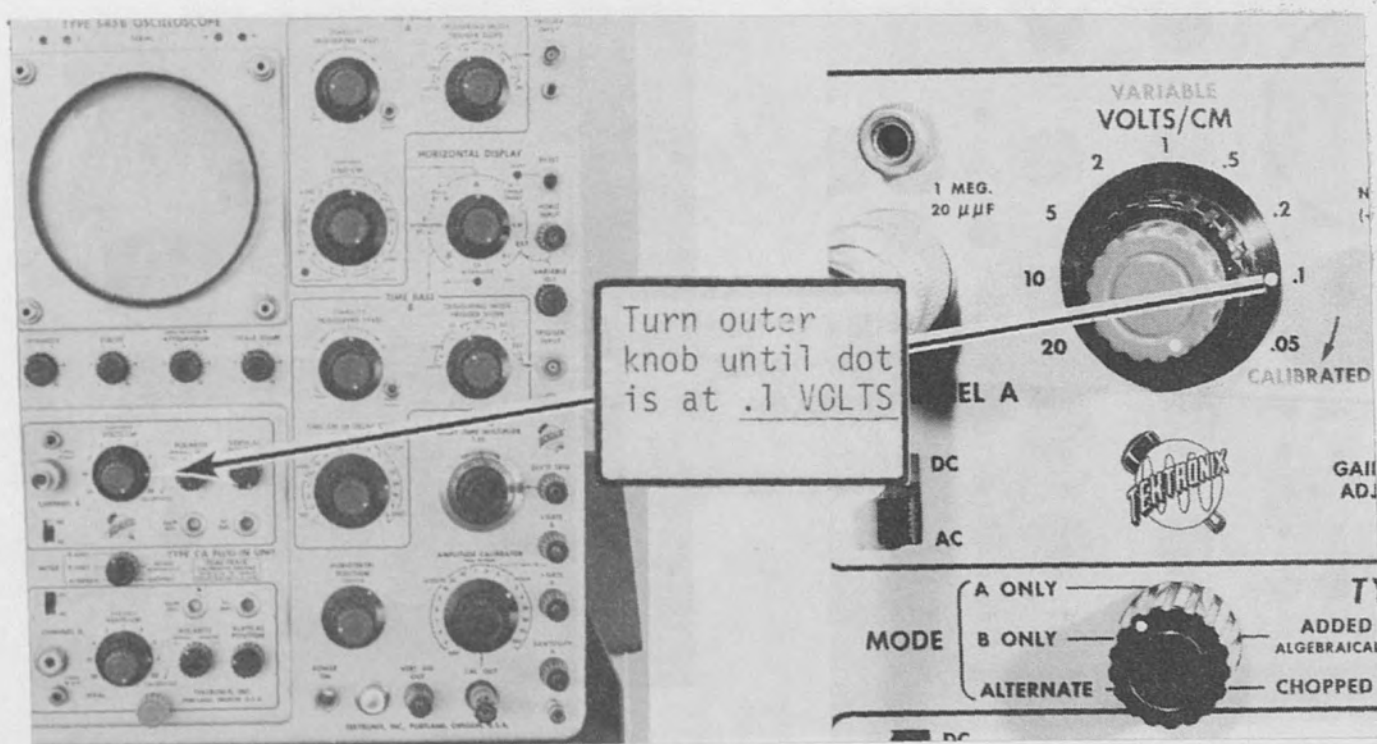
2. To check your answers turn back to page 57.

TRAINING

Step 17: Set CHANNEL A VOLTS/CM to .1 volts

Purpose: With this switch you can set the value of each square on the vertical axis of the CRT scale.

ACTION



CHECK YOUR MEMORY

Directions: 1. Point through the action on the foldout.

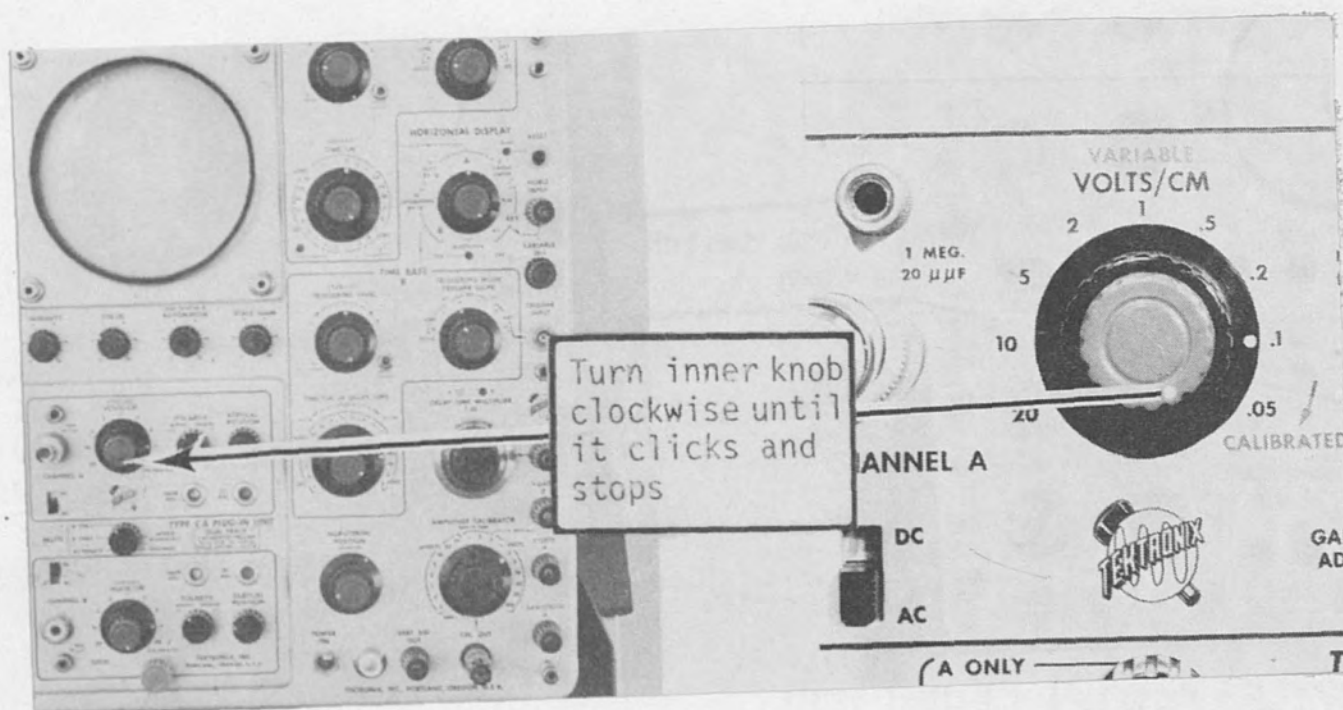
Action _____

2. To check your answers turn back to page 59.

TRAINING

Step 18: Set VARIABLE VOLTS/CM switch to CALIBRATED.

Purpose: Ensures that values set in step 17 do not fluctuate.

ACTION

CHECK YOUR MEMORY

Directions: 1. Point through the action on the foldout.

Action _____

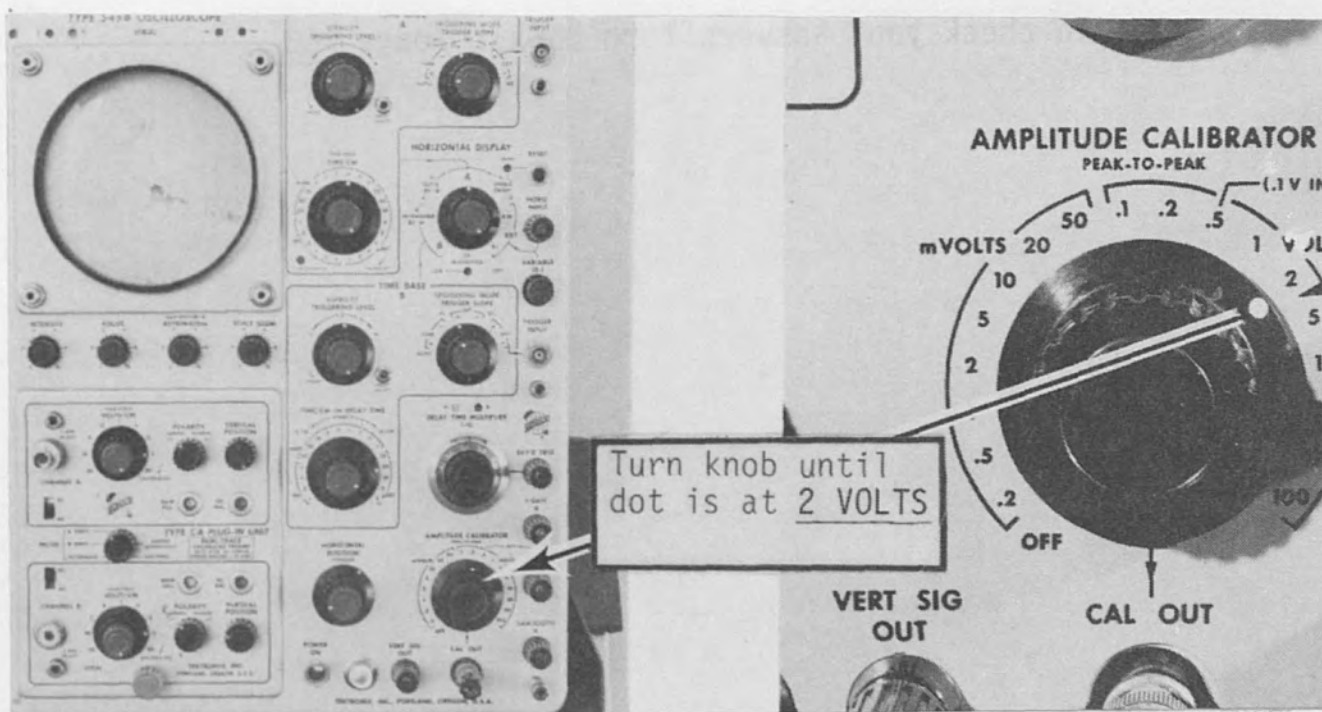
2. To check your answers turn to page 61.

TRAINING

Step 19: Set AMPLITUDE CALIBRATOR to 2 volts.

Purpose: Defines the height of the square wave that will be displayed in the next step.

ACTION



NOTE

There are two scales on this knob. One for 1/1000 VOLTS (m volts) and one for VOLTS. Be sure to use the correct one.

CHECK YOUR MEMORY

Directions:

1. Point through the action and response(s) on the foliot and recall the note for this step.

Action _____

Note _____

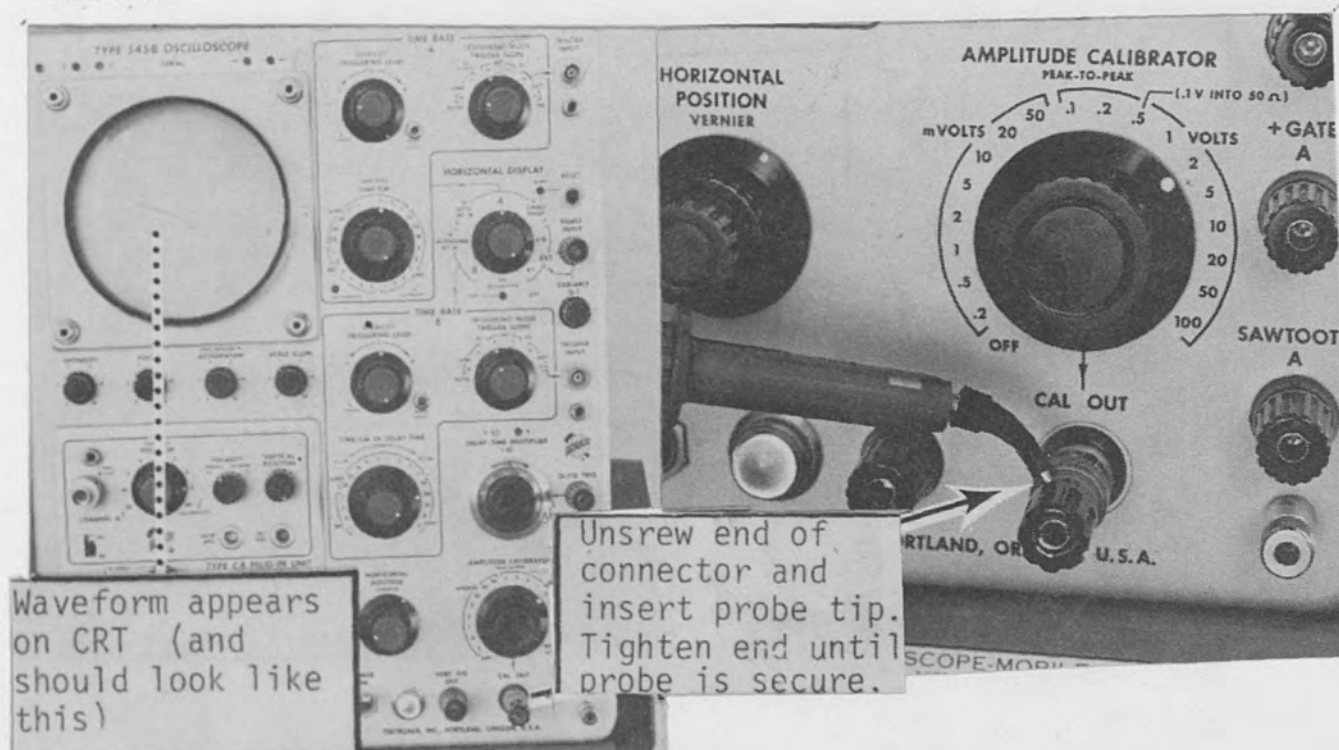
2. To check your answers turn back to page 63.

TRAINING

Step 20: Insert probe tip into CAL OUT connector.

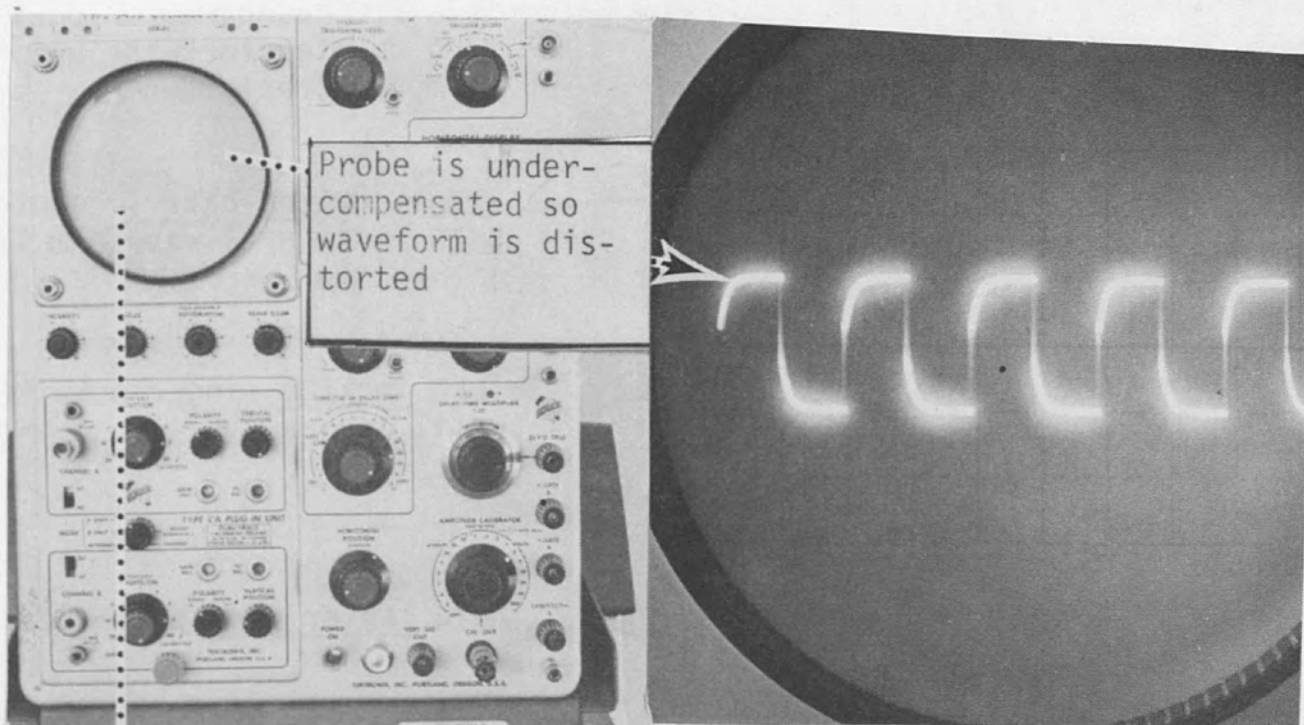
Purpose: So the signal generated at the CAL OUT connector can be displayed on the CRT.

ACTION

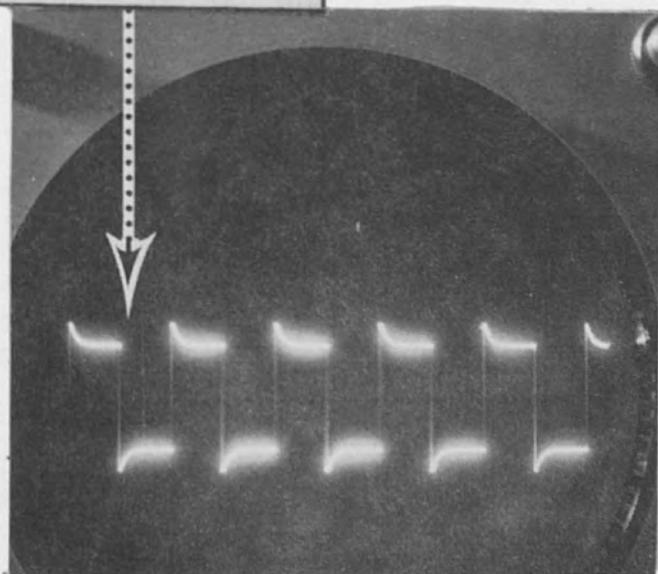


Step 20: Insert probe tip into CAL OUT connector (continued)

WHAT CAN GO WRONG



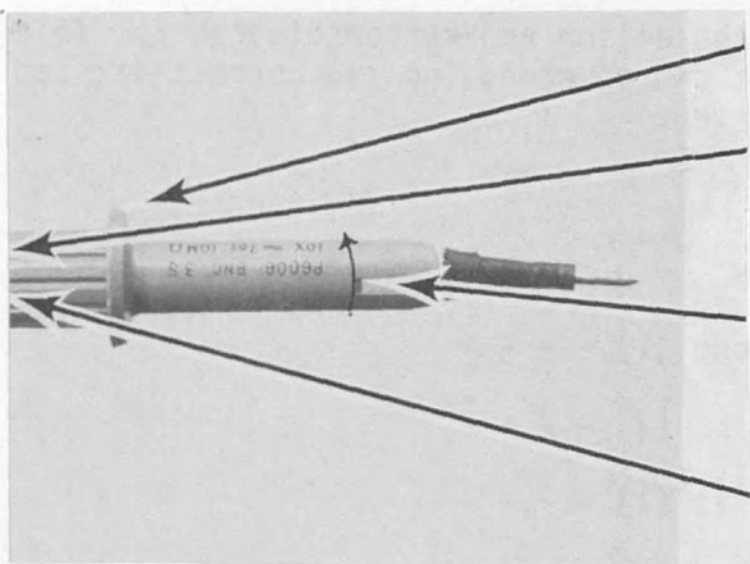
Probe is over-compensated so waveform is distorted



Step 20: Insert probe tip into CAL OUT connector (continued)

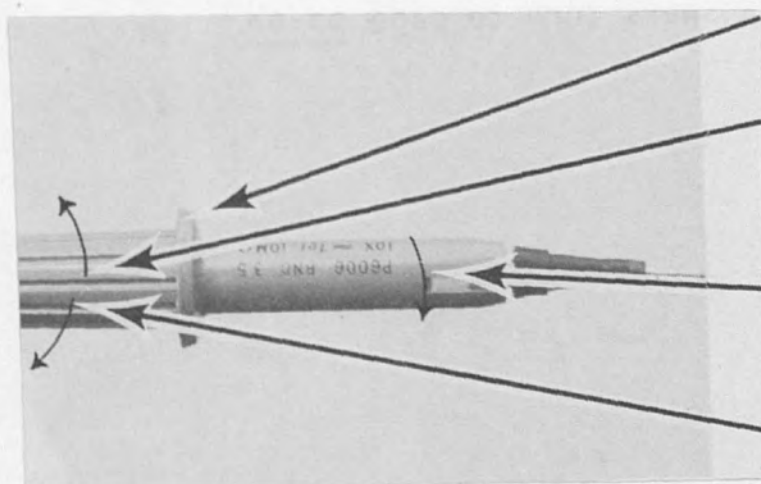
HOW TO CORRECT IT

Under compensated probe



1. Hold center ring.
2. Turn locking ring counterclockwise until it moves freely.
3. Rotate tuning barrel clockwise until waveform is square.
4. Turn locking ring clockwise until secure.

Over compensated probe



1. Hold center ring.
2. Turn locking ring counterclockwise until it moves freely.
3. Rotate tuning barrel counterclockwise until waveform is square.
4. Turn locking ring clockwise until secure.

CHECK YOUR MEMORY

- Directions:
1. Point through the action and response(s) on the foldout and recall what can go wrong and how to correct it for this step.

Action _____

Response(s) _____

What can go wrong (1) _____
(2) _____

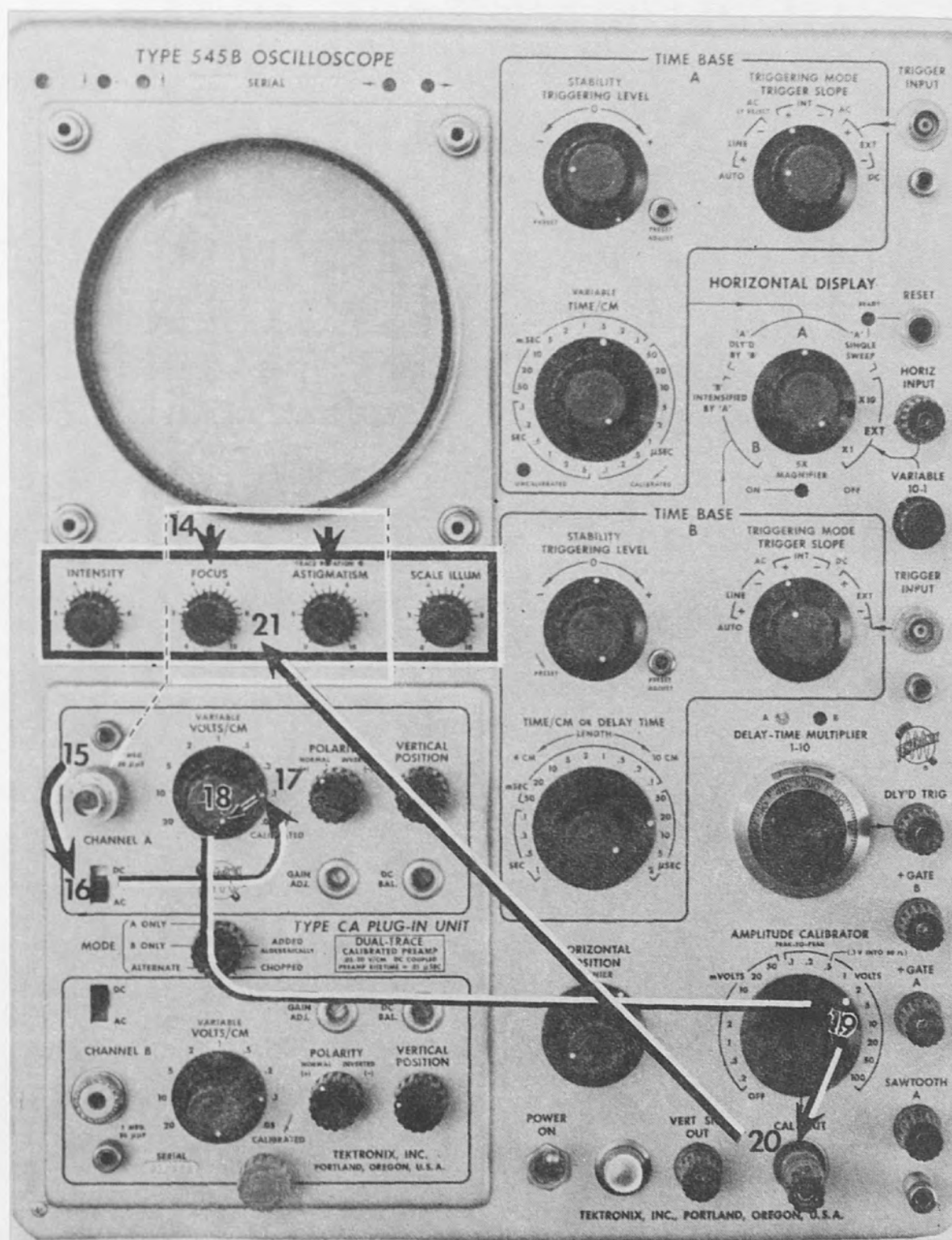
How to correct it (1) _____
(2) _____

2. To check your answers turn to pages 65-67.

STEP SEQUENCE DRILL

Directions:

1. Follow the "roadmap" on the next page and trace the sequence of steps with your finger.
2. Remember the location and sequence of each control used.



STEP SEQUENCE DRILL (cont.)

Directions:

1. Use your finger and trace the step sequence you just learned, on the foldout (page 116).
2. To check your performance look back at the "roadmap" on page 72.
3. Keep practicing until you can trace the step sequence without looking back or making any mistakes.

TEST YOURSELF

- Directions:
1. Describe in your own words the activiteis for each step listed below and point on the foldout to the controls used in each step.
 2. If you need to check your answers: look on pages 75-77.
 3. If you make mistakes: practice the steps you miss and keep taking the test until you make no errors.

Step 16: Set CHANNEL A DC/AC
coupling switch to AC

Action

Step 17: Set CHANNEL A VOLTS/CM
switch to .1 volts

Action

Step 18: Set VARIABLE VOLTS/CM
switch to CALIBRATED

Action

Step 19. Set AMPLITUDE CALIBRATOR
to 2 volts

Action

Step 20: Insert probe tip into
CAL OUT connector

Action

Response

What can go wrong

How to correct it

PAY SPECIAL ATTENTION TO THE STEP LOCATION AND SETTINGS.
YOU WILL HAVE TO KNOW THEM ALL ON THE FINAL TEST.

TEST ANSWERS

Step 16: Set CHANNEL A DC/AC coupling switch to AC

Purpose: In this procedure only AC signals need to be displayed.

Step 17: Set CHANNEL A VOLTS/CM switch to .1 volts

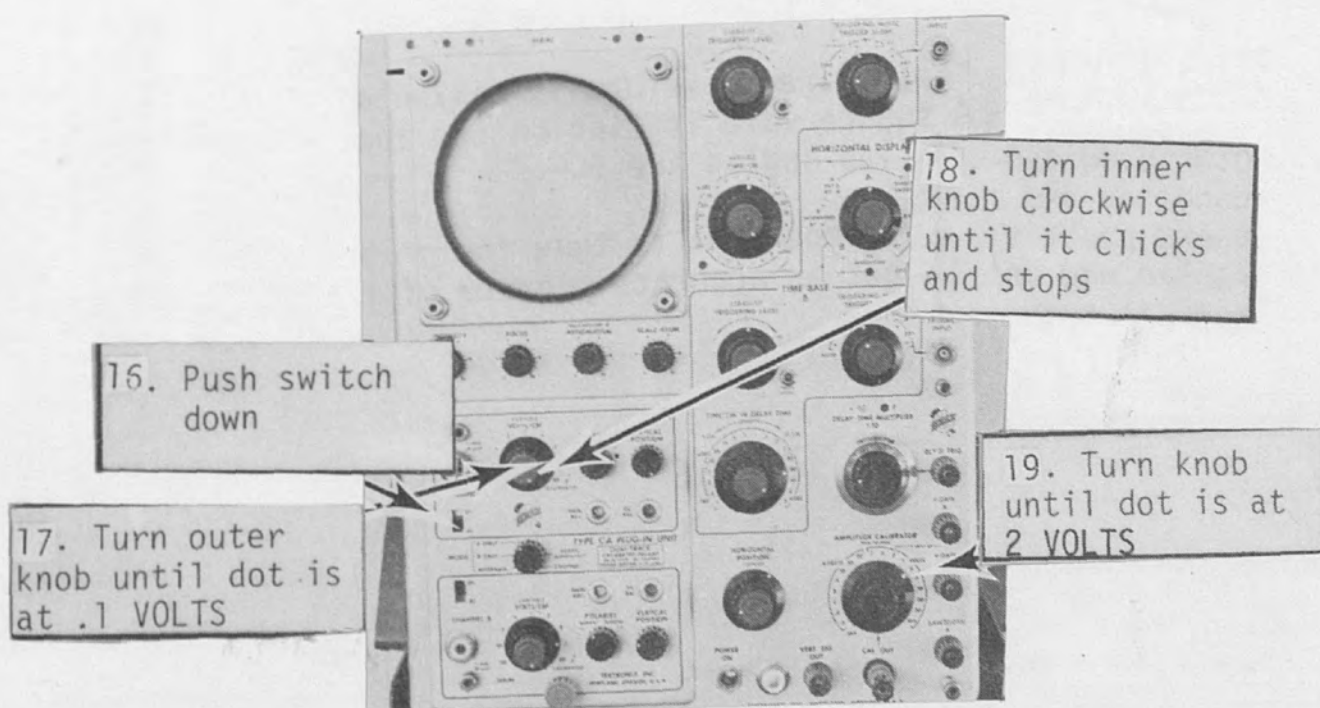
Purpose: With this switch you can set the value of each square on the vertical axis of the CRT scale.

Step 18: Set VARIABLE VOLTS/CM switch to CLAIBRATED.

Purpose: Ensures that values set in step 17 do not fluctuate.

Step 19: Set AMPLITUDE CLAIBRATOR to 2 volts.

Purpose: Defines the height of the square wave that will be displayed in the next step.



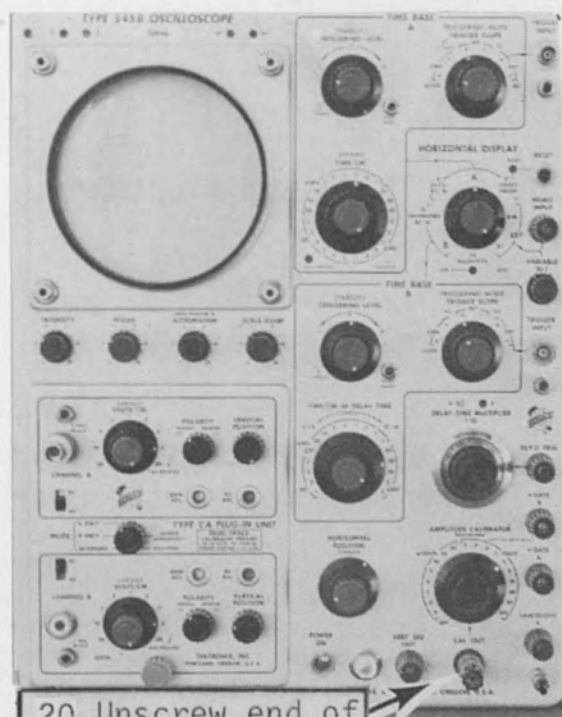
Step 20: Insert probe tip into CAL OUT connector

Purpose: So the signal generated at the CAL OUT connector can be displayed on the CRT.

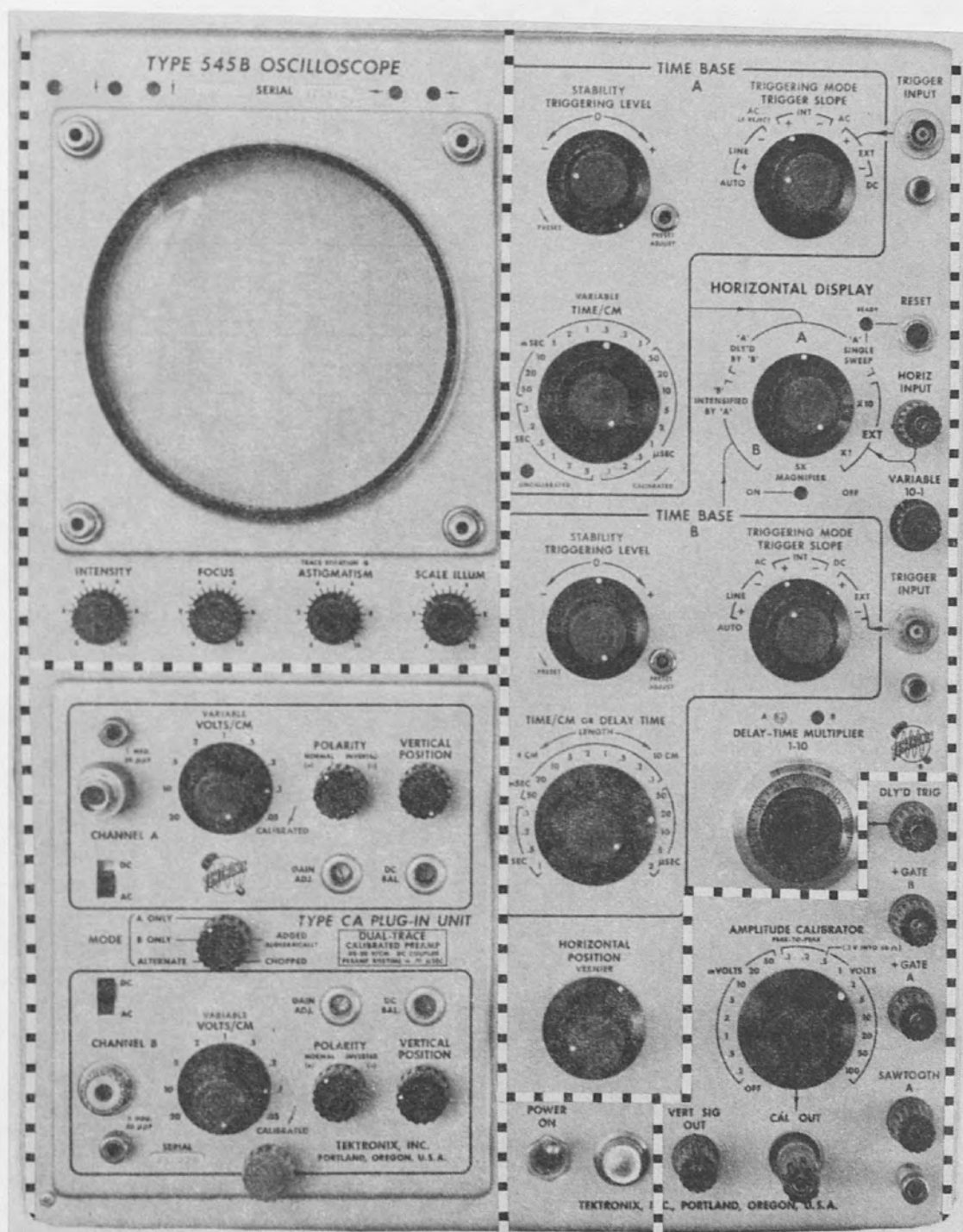
Response: Waveform appears on CRT.

What can go wrong: 1. Probe is under compensated.
2. Probe is over compensated.

How to correct it: 1. (a) hold center ring of probe.
(b) turn locking ring counter-clockwise until it moves freely.
(c) rotate tuning barrel clockwise until waveform is square.
(d) turn locking clockwise until secure
2. (a) hold center ring of probe.
(b) turn locking ring counter-clockwise until it moves freely.
(c) rotate tuning barrel counter-clockwise until waveform is square.
(d) turn locking ring clockwise until secure.



20. Unscrew end of connector and insert probe tip. Tighten end until probe is secure.



Appendix D

Procedure Learning Guidelines

TAEG Report No. 23

I. RECALLING PROCEDURES AND POSITIONING MOVEMENTS

This task category combines two quite different kinds of tasks. Recalling procedures is basically a mental skill, whereas positioning movement is a physical skill. They are combined in these guidelines since they often occur together in the operation setting. They concern carrying out routinized activity, executed as standard operating procedures in some predetermined sequence. Relatively little judgment and analysis are required and a minimum of alternative behavior is involved. Controls are manipulated in an identifiable procedural sequence. Motor movements for control positioning are, at the outset, within the response repertoire of the student; therefore the emphasis is placed on recalling the sequential procedures and on the accuracy of the positioning movements. An example is the check-out of a piece of communication equipment using a checklist to determine if the equipment is operating within acceptable tolerances. These types of tasks are common and have often been studied with the goal of improving training efficiency.

Guidelines for this behavior are listed below.

1. State clearly the behavioral objectives to be achieved. Describe how the learning materials are organized to achieve this desired behavior. Relate the objectives to the student's future real-world assignments.
2. Break the positioning movement task into appropriate parts and provide subdivisions of organization for each procedure.
3. Divide the procedural steps into small parts if any of the following conditions exist:
 - a. Students are of low ability
 - b. The procedures are complex
 - c. The entire procedure is lengthy.
4. Present a demonstration of each task performance (a positioning response to a checklist cue) on an observable model.
5. Show checklist cues and require the student to explain differences in similar cues that serve as association devices for different procedures that have been confused in the past.
6. Use mnemonics which will cause an affective reaction in the student whenever possible to aid in the recall of the procedure to be learned for this task.

7. Use mnemonics (associating procedural steps with imagery, rhymes, or rhythms) to aid in recalling difficult to remember steps. Provide directions for the student to develop his own mnemonics where he is able and willing to do it.

8. Direct the student to practice the following sequence of events to help him remember a chain of procedures.

a. When presented with each checklist item, explain its corresponding procedural step.

b. Then when presented with a group of checklist items explain or perform their corresponding procedural steps. The first item of each group should overlap the last item of the previously studied group of steps.

c. Then when presented with a single list of all of the checklist items in the entire procedure, explain or perform their corresponding steps.

9. Encourage students to mentally rehearse the procedures called for by the steps in the checklist using mnemonics to aid in the recall of these procedures.

10. Ensure extensive practice early in the training by requiring the learner to:

a. Understand the objective(s)

b. Observe the skilled performance of a model

c. Strengthen the individual steps of the desired movement by practicing these steps, obtaining knowledge of results and by correcting performance errors.

d. Integrate the steps into a smooth sequence of positioning movements by practicing the sequence of steps.

11. Provide the following conditions for corresponding stages of training:

a. Early in training use:

(1) immediate and frequent knowledge of results

(2) immediate and frequent reinforcement

(3) little or no operational distractors

(4) learning material broken down into small, easily learned parts

(5) items required to be learned which are relatively easy to acquire

(6) guiding or prompting of responses

b. Late in training:

(1) use delayed and infrequent knowledge of results

(2) use delayed and infrequent reinforcement

- (3) increase distractors to operational level
- (4) a given procedure will be required to be recalled in response to the same cues as on the job
- (5) the level of complexity of the procedural cues and distractor cues should be the same as on the job.
- (6) eliminate guide or prompts

12. Make the time interval following KOR much longer than the time interval between the response and KOR, to provide time for the student to sort out errors.

13. Identify features of the operational environment which could be used as mediators to trigger the student's recall of checklist items.

14. Practice should be distributed; i.e., the timing of rest periods should be determined by:

- a. need for rest as judged by the student
- b. requirements of the specific learning material as judged by the instructor

15. Arrange for extensive repetition (overlearning) by the student to take advantage of the internal feedback properties generated by performing these types of tasks (positioning movements) accompanied by external feedback. Simple repetitive movements may become reinforcing; i.e., the student experiences feelings in muscle and joints which identifies as cues that he is properly performing the task.

References

- Aagard, J. & Braby, R. Learning guidelines and algorithms for types of training objectives (TAEG Report No. 23). Orlando, Florida: U.S. Navy Training Analysis and Evaluation Group, 1976.
- Ainsworth, J. Symbol learning in Navy technical training: An evaluation of strategies and mnemonics (TAEG Report No. 66). Orlando, Florida: U.S. Navy Training Analysis and Evaluation Group, 1979.
- Booher, H. Relative comprehensibility of pictorial information and printed words in proceduralized instruction. Human Factors, 1975, 17 (3), 266-277.
- Braby, R., Parrish, W.P., Guitard, C.R., & Aagard, J. Computer-aided authoring of programmed instruction for teaching symbol learning (TAEG Report No. 58). Orlando, Florida: U.S. Navy Training Analysis and Evaluation Group, 1978.
- Catano, V. Preparation of aircraft engines under programmed learning procedures. Perceptual and Motor Skills, 1976, 42, 540-542.
- Coleman, L.L. An experiment in programming the care and use of mechanics' hand tools. In G.D. Ofiesh & W. Meierhenry (Eds.), Trends in programmed instruction. Washington, D.C.: National Education Association, Dept. of Audiovisual Instruction, 1964, 136-138.
- Dansereau, D.F., Long, G.L., McDonald, B.A., Atkinson, T.R., Ellis, A.M., Collins, K., Williams, S., & Evans, S. Effective learning strategy training program: visual imagery for effective learning (AFHRL -TR-45-47). Lowry AFB, Colorado: Air Force Human Resources Laboratory, Technical Training Division, 1975.
- Dwyer, F.M. The relative effectiveness of varied visual illustrations in complementing programmed instruction. The Journal of Experimental Education, 1964, 36, 34-42.
- Gibson, C.R. A theory of pictorial perception. Audio-Visual Communication Review, 1954, 11, 3-23.
- Guitard, C.R. Computer-aided authoring system (AUTHOR) user's guide (TAEG Report No. 59). Orlando, Florida: U.S. Navy Training Analysis and Evaluation Group, 1978.
- Haber, R.N. How we remember what we see. Scientific American, 1970, 222 (3), 104-112.

- Hartman, F.R. Single and multiple channel communication: A review of research and a proposed model. Audio-Visual Communication Review, 1961, 9 (6), 235-256.
- Jenkins, A.M. Imagery and learning. British Journal of Psychology, 1935, 26, 149-164.
- Lang, J. & Melton, J.E. Mechanical training with the K-38 revolver. In G.D. Ofiesh & W. Meierhenry (Eds.), Trends in programmed instruction. Washington, D.C.: National Education Association, Dept. of Audiovisual Instruction, 1964.
- Miller, N.E. Graphic communication and the crisis in education. Audio-Visual Communication Review, 1957, 5 (3), (Special Supplement).
- Naylor, J.C. & Briggs, G. Effects of rehearsal of temporal and spatial aspects on the long-term retention of procedural skills. Journal of Applied Psychology, 1963, 47, 120-126.
- Roshal, S.M. Effects of learner representation in film-mediated perceptual motor learning (Technical Report No. SDC-296-7-5). University Park: Pennsylvania State University, Instructional Film Research Program, 1949.
- Severin, W. The effectiveness of relevant pictures in multiple channel communications. Audio-Visual Communication Review, 1967, 15 (3), 84-95.
- Smith, E.E. Imaginal versus verbal coding and the primary-secondary memory distinction. Journal of Verbal Learning and Verbal Behavior, 1971, 10, 597-603.
- Stitch, T.G., Fox, L.C., Hauke, R.N., & Zaph, D.W. Reading in the Navy (Final Report No. HumRRO-FR-WD-CA-76-14). Alexandria, Virginia: Human Resources Research Organization, 1976.
- Wicker, F.M. On the locus of picture-word differences in paired associate learning. Journal of Verbal Learning and Verbal Behavior, 1970, 9, 52-57.
- Winer, B.J. Statistical principles in experimental design. New York: McGraw-Hill Co., 1962, 337-348.